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USSR: Engineering & Equipment

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'Radioactive' Procurator

917F0142A Moscow INZHENER in Russian No 12, 90 pp 2-4

[Article by P. Penezhko: "'Radioactive' Procurator"]

[Text] A paper, signed by the Minister of Heavy Machine Building V. M. Velichko and his colleague for USSR Nuclear Power Engineering and Industry V. F. Konovalov, arrived at Gosarbitrazh SSSR at the beginning of this year. It discussed the financial claims against the Podolsk Machine Building Plant imeni Ordzhonikidze, which had essentially manufactured faulty steam generators for nuclear power plants. The losses, according to the highest decision, had to be related "to the cost of electric power and review of the planned and economic indicators of AES if necessary."

And at this time, a typewriter chattered like a machine gun in the city procurator's office of Yuzhnoukrainsk.

"Ten steam generators, manufactured by the Podolsk Machine Building Plant imeni Ordzhonikidze of the USSR Ministry of Heavy Machine Building, have now failed at the Yuzhnoukrainskaya AES. The cost of each generator is more than 3.5 million rubles. The total loss to the national economy at our plant alone was approximately 40 million rubles. Goskomtsen of the USSR established an incentive bonus to its cost of 110,000 rubles for awarding steam generators of this type the State Emblem of Quality in 1986. The nuclear power plants paid these bonuses without a murmur. However, very brief operation of these steam generators showed that the Emblem of Quality was, in short, assigned to them, too quickly. The Emblem of Quality was taken away, but Goskomtsen of the USSR for some reason did not think that the producer of faulty goods should return the unearned money to all purchasers, that these sums are essentially an incentive for production of defective goods! The procurator of Yuzhnoukrainsk is junior counselor of justice D. Molchanov."

We became acquainted in Moscow on a rainy evening, when he was nervously wandering the hotel, having just returned from hearing the matter in arbitrage. Again everything ended unsuccessfully.

"There is no law about nuclear power engineering. This is a disgrace! We were the first in the world to construct a nuclear power plant. Nuclear legislation has been adopted since the 1940's-1950's in the United States, Japan, West Germany, and France."

"Do we have few ineffective laws?"

"And even so they will never be able to do what they are shamelessly doing now within the law. They are trying with every effort to see that this legislation is not adopted. Six years ago, a legislative project that takes into account all the abundant international experience was worked out at the Institute of Government and Law. If the government had adopted it then, Chernobyl would probably not have happened. For example, it contains an article that forbids any type of experiments at nuclear power plants. But the main thing, according to the law, both Gosatomenergonadzor [not further identified] and the KGB are supposed to inform me about all violations in the operation of a nuclear power plant."

"Who do they inform now?"

"Party organizations. I now find myself in the position of procurator of Pripyat D. Polishchuk, who, from 1981 until the catastrophe itself, indefatigably watched over the plant, without having 'noticed' a single violation in its operation, although systematic violations of regulations occurred there, and the power-generating units were shut down many times through the fault of personnel. What kind of procurator is this when no inquiries were conducted even by the administration in 27 of 71 cases of emergency shutdowns!"

"In human terms, of course, one can understand our atomic scientists, who do not very much want to be frank with you. After all, it is written about you in any Soviet encyclopedia that the procurator occupies the position of State accuser. After all, this sounds somewhat different with Dal. He calls procurators public servants who observe the valid application and precise version of laws. However, you are primarily the accuser in the public perception, with whom it is best not to deal."

"Prejudice! But, incidentally, do not the trade unions also not inform anyone about events at power plants, as this is understood?"

"It looks like they are ready to accept this."

"But I am not ready. However, it looks as if it is worth my approaching this delicate question—there is a danger—since the management of the power plant has already stated that it is no affair of mine, that I am incompetent, that 20 controllers are already involved with this at the plant, among whom there are 7 inspectors of Gosatomenergonadzor, and even that their pay is much higher than mine. So that they have no position for a procurator inspector."

"It is a paradox, but no place was found in the President's council for a General Procurator, although it includes at least two ministers, whom he is obligated to advance. What is this, some kind of delayed reaction to the heritage of Vyshinskiy's sad memory, the godfather of 'the Czarina's demonstations'?! At the same time as the MVD and KGB are at the height of criminality, foreign failures and on the lookout for dissidents, they have dared to raise their wages, increase their staffs, win the favor of the press, arouse the imagination of writers and filmmakers, the procurator's office kept in the background, with miserly staff, equipment and wages. It is no secret to anyone that there was the fine idea in many detective productions: the most serious obstacle in the path of righteous government are these thoughtless people, bureaucrats and retrogrades—generally procurators."

Just between us, Molchanov is indeed a "retrograde." History confirms this, as his claim arose against the Podolsk plant. Having found out that the failed generators are being replaced at the plant, he demanded documents that show the causes of this "incident," sad for the State and hazardous to the public (as now it has become accepted to speak about the nuclear scientists). This time, the plant, for quite understandable reasons—everyone remembers Chernobyl—was not satisfied with this. The papers indicated with all certainty: there are ruptures in the headers of the steam generators due to faulty design and faulty technology of manufacture at the Podolsk Plant.

However, another large pile of documentation was sent from the plant, accusing the power plant of permitting deviations in the chemical environment of the secondary circuit. Experts of the USSR Academy of Sciences and of the Ukrainian Academy then concluded with "Solomon's wisdom" that all three factors had interfered—design, manufacture and disruption of the medium. The guilt was "shared" by all three, but there was really no guilt.

This can not be the procurator said to himself. Somebody's guilt must be greater: either that of the designer, that of the manufacturer, or that of the operator. Having decided to conduct an independent expert review, he appealed to a professor from the Department of Nuclear Power Plants of the Moscow Power Engineering Institute V. Gorbatykh. But the professor demanded 10,000 rubles to conduct a scientific study. Not only does procurator Molchanov not have this money, but neither does the entire procurator's office of the USSR.

Intelligent people advised Molchanov not to be saddened too much. After all, the same Gorbatykh threatened in the summer of last year to estimate the operation of the steam generators at decades, demanding that the power plant pay him the same 10,000 rubles (obviously his favorite sum). He did not give the professor one kopeck and acted correctly. No sooner had the disappointed scientists left the power plant than two "ruptured" headers of the steam generators immediately "saluted" his departure.

No, the department of MEI, the head of which Professor Rassokhin received the State Prize for his textbook on the "explosive-hazard" steam generators, and their developer received the prize—the general designer of the OKB [Special Design Office] Gidropress V. Stekolnikov—a doctor of technical sciences, and the chief designer of the Podolsk plant V. Grebennikov, who embodied them in metal, almost received his doctorate (he was unable to answer the question of his opponent: "colleague, why do you have a linear equation, but there is a curve on the graph?"),—no it is not here, the procurator must seek the scientific truth. He appealed to the Nikolayev Shipbuilding Institute (where steam generators are an understandable matter and more than one person has studied them), and there he was given a list not only with all certainty, but quite free of charge, that the composition among the secondary circuit has nothing to do with accidents in the given case.

Doctor of physicomathematical sciences V. Rybin conducted investigations at the Yuzhnoukrainskaya AES and confirmed the opinion of his colleagues, so to say, experimentally. The Odessa Technological Institute confirmed that the design and technology and manufacture are entirely at fault. Corresponding members of the Ukrainian SSR Academy of Sciences O. Romaniv and A. Andriykiv and doctor of technical sciences G. Nikiforchin agreed with this, noted that they feel that operation of this equipment is impermissible. All agreed that the poor design of Stekolnikov and the steel, incorrectly selected by Grebennikov, and the manufacturing technology were guilty. Molchanov felt that if the losses due to replacement of all the failed steam generators had to be added to the cost of the electric power not generated during the idle times, the total would be approximately 1 billion rubles! This was hardly the reason for the complaint against the designers and manufacturers!

The procurator of Yuzhnoukrainsk still did not know at that time that there was already experience of a similar claim, having proved complete and dejecting lack of results. And that the city procurator did what the Ministry of the USSR was unable to achieve. We are now talking about the retired minister of nuclear power engineering N. Lukonin, who demanded of Gidropress and the Podolsk machine builders that they make up the losses of the Novovoronezhskaya AES, which the steam generators

"punished" for 14 or more million rubles. L. Ryabev then headed Minsredmash, and the same V. Velichko headed Tyazhmash, and they both assured N. Lukonin that the design and technology of manufacture of the steam generators would be changed and that their reliability would be universally improved.

At the time Gosarbitrazh procrastinated and procrastinated with consideration of claims until L. Ryabev transferred from Sredmash to the chair of the Deputy Chairman of USSR Sovmin on the Fuel and Energy Complex and until Minatomenergo "merged" with Minsredmash, having first "splashed out" on the pension of the obstinate Lukonin. This new equipment cocktail includes Minatomenergoprom, where claimants and respondent were mixed, the Novovoronezh claim was seemingly canceled, and everything seemed to be okay (with the exception of the cost of electric power of course). But then this Yuzhnoukrainsk procurator swooped down from the sky with his claim for 12 million rubles.

But if justice was found for the minister, what about the city procurator. Ministers Velichko and Konovalov sent to Gosarbitrazh a threatening letter, the sense of which is that, if Ryabev carried this almost one billion ruble loss because of 26 failed steam generators to the cost of

electric power, then there can be no talk about any kind of new claims. Molchanov's claim was naturally "skidded" here.

Dealings with the academies of sciences, which, although they did not reject the procurator experts, and do not wish to name the guilty parties, proceeded on a different tack. And in principle this is not their affair. After all, the court should be involved rather than arbitrage. But can the ministers be put in the dock? Even for the fact that their enterprises are supplying nuclear power plants with unreliable and simply hazardous equipment?! No, the intermediaries have an answer for everything.

"Such a petty matter will not proceed in the civil or criminal court," says Molchanov angrily, "without the procurator's supervision of the legality. And Gosarbitrazh, where millions of claims are disputed, deals with them. There are only 20-odd persons there, but up to 15 claims come in to each one of them every day. Multimillion ruble claims are confusing. With this load, it is difficult to proceed intelligently, and even more to observe the legality. And sometimes the same worker of Gosarbitrazh adopts opposite solutions on the same question at different times. So that they are not guided by the law, but by an arbitrary coincidence of circumstances."

And sometimes the Podolsk steam generators of Stekolnikov-Grebennikov are brought to the nuclear power plants, so to say, "underhandedly." Similar to our kolkhoz-sovkhoz workers, they reach the rank of scheduled loss steam generators (Zaporozhskaya, Novovoronezhskaya, Yuzhnoukrainskaya, and Balakovskaya AES). A total of 25 million rubles was allocated for them from the State budget last year. Aren't there conversations that our electric power is very inexpensive and that the cost should be raised?

From the time that Molchanov first crossed the threshold of the Yuzhnoukrainskaya AES, he is amazed at how easy it is to "rip off" unearned money from the plant. The designers of the Kharkov Branch of Atomenergoproyekt received at least 1.5 million if not more for the high quality of the third power-generating unit. But there were 1,600 (!) errors in accounting for the construction. Or let us say 213 dosimetric monitoring holes had to be drilled around the unit according to the design. And suddenly a joint "miracle" comes from the dosimetric service and from the designers themselves—90 holes are sufficient. The State pays for "the economic impact" without a murmur.

But according to a healthy discussion, there is only one "impact" here—either careless predesign studies or clear disregard of safety. In any case, this is poor work, which is nevertheless rewarded in some perverted manner.

"And perhaps they intentionally design any types of nonsense," the procurator thinks, "so as to appear to be innovators, keeping busy, and can demonstrate their need to society?"

Molchanov's primary education is engineering. Therefore, when he saw a crack with "spreading edges" in the 170-millimeter wall of the steam generator header, he immediately understood that this was not the result of high internal stress. This is somehow comparable to stress, which requires that Molchanov inspect the AES. Afte all, its director is subordinate to the union ministry and this means that the city procurator must raise his protest through all the hierarchical steps up to the Procurator General. And a basket for papers is on the watch for each of his protests.

Molchanov was preparing to leave the Rossiya Hotel when suddenly he saw through the window that a crowd carrying placards reading "Save our children!" was moving in the direction of Spasskaya Tower. These were residents of regions of Belorussia that had been exposed to radiation. Molchanov fell into their crowd and together they went to the hall of Sovmin. People began to come forward. One says there are no resources. Others say that it is the bureaucrats. In the procurator's opinion, this is not true at all. And the procurator spoke. "The law," he says, "should be about nuclear power. Without it there will be no increased criminal responsibility for a nuclear accident, which must be raised to the rank of State crimes. The monitoring organizations will then receive effective plenipotentiary powers, and the procurator will be able to ensure that the monitoring organizations see that the AES administration obeys the law."

"I do not wish," he says, "to receive orders and medals for elimination of the consequences of the accident. I want the power plant to be operated safely and I want to see that my 2-year-old son never encounters what his Chernobyl peers have to cope with."

Thus, the procurator of a small Ukrainian town is going against two mighty union ministries. A little more than 2 years ago, the fate of this struggle would have been already decided. Now, it's hard to say. One thing is clear that in the little more than 4 years since Chernobyl, we have come closer to a legal government than during all the previous 70 years.

Mathematical Model of Heat and Mass Transfer Processes in Solar Hothouse-Dryer with Underground Heat Storage

917F0161B Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 20-26

[Article by B.E. Khayriddinov, M.Kh. Ashibayev, and B. Nuriddinov, Scientific-Industrial Association "Solntse" (Sun), TuSSR Academy of Sciences]

UDC 662.997

[Abstract] Design of solar hothouse-dryer compounds with underground heat storage, the combination of hydrodynamic and thermal processes in them is described by two systems of partial differential equations. Those pertaining to the dryer are: 1) two equations of vertical (z) motion and horizontal (x) motion respectively, 2) equation of continuity, 3) two equations of desiccant mass transfer and heat transfer respectively. Those pertaining to the underground heat storage, a horizontal cylindrical bed of clastic material, are: 1) three equations of vertical (z) motion and horizontal (x,y) motion, 2) equation of continuity, 3) equation of energy flow through the layer of packing, 4) equation of heat conduction through the clastic bed. To these equations are added equations of heat conduction through radiation reflecting structures in the hothouse-dryer compound, both packing porosity and bed transparence distribution laws, and conditions of contact. All these equations are not easily solvable even with the aid of a computer. Theoretical estimates and experimental data indicate that the horizontal gradients of heat carrier speed and temperature are so much smaller than their vertical gradients as to be negligible, also that the heat carrier flows much faster radially than longitudinally. Some of the equations have accordingly been eliminated. Other equations have been modified, taking into account the pattern of heat carrier flow through the underground packing and the humidity of air flowing through the dryer, for simpler for calculation of the heat transfer coefficients on which the drying of produce and the storage of heat depend. The temperature at the surface of the produce stack is then calculated by solving the system of Lykov's two partial differential equations for the appropriate boundary conditions and by using applicable expressions for the mass transfer potential. Analogously is calculated the temperature of air leaving the underground heat storage bed. The equation of heat conduction is modified twice, for calculating the temperature of the heat carrier flowing through the underground bed and the temperature at the surface of clastic bed respectively, and then again with the equation of heat balance added for calculation of the soil around the heat storing bed. The model has thus been reduced to eight partial differential equations with boundary conditions for each. Experimental data confirm its validity and adequacy for predicting the performance of a hothouse-dryer compound with underground heat storage in the design stage. Figures 1; references 7.

Nonsingle-Crystal Silicon and Conversion of Solar Energy

917F0161D Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 38-46

[Article by M.S. Saydov, Institute of Engineering Physics, Scientific- Industrial Association "Fizika - Solntse" (Physics - Sun), UzSSR Academy of Sciences]

UDC 621.362:621.383.5

[Abstract] Scientific research and experimental engineering done since done since 1954 on the use of amorphous and polycrystalline silicon in solar cells is overviewed, including the latest state of the art as of 1989. The report contains pertinent design, performance, and cost data obtained from the Soviet and foreign sources. According to this survey, the efficiency of a-Si and poly-Si solar cells will increase with improvements in the silicon technology and in the design of solar plant structures. Technological improvements will include passivation of silicon, implantation of a microcrystalline component into amorphous silicon, use of superlattices, hetergeneous and buffer layers. Structural improvements will include staging for separate and thus more efficient conversion of energy within narrow ranges of the radiation spectrum and combined utilization of its entire spectrum, use of concentrators, and utilization of thermal effects. High efficiency of solar cells will ultimately become attainable with the silicon microstructure and grain size ceasing to be significant factors, after extraneous causes of degradation such as tunneling p^+- n^- homojunctions and heterojunctions have been removed. Figures 10; references 56.

Radiative Heat Transfer in Systems of Bidirectionally Reflecting Mirrors in Solar Power Plants

917F0161C Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 26-30

[Article by B.A. Khrustalev (deceased) and R.K. Ragimov, State Scientific Institute of Energetics imeni G.M. Krzhizhanovskiy]

UDC 536.3:535.312

[Abstract] Radiative heat transfer in the sun-mirror-receiver system in a solar power plant is analyzed, with the bidirectional reflection characteristics of the mirrors taken into account so that scattering of solar radiation by their dirty or wet surfaces can be included. The analysis is based on the classical theory of radiation transfer in the approximation of geometrical optics, rather than on the Aparisi formula with an empirical correction factor accounting for nonideality of the mirror surface. The radiant flux density at a point on the receiver surface is calculated by integrating over the surface of the radiation source, in this case the visible solar disk, and over the surface of all mirrors. The

intensity distribution in the beam of solar radiation reflected by a mirror is calculated next, this distribution depending on a scattering parameter $R_S v_0$ (solar radius R_0= 46.54x10^4 rad, v_0- reflection angle at which the bidirectional reflectivity $\rho^{S'S}$ is e times smaller than the specular reflectivity of a mirror. Into account are taken transmittivity of the atmosphere. Figures 2; references 5.

Testing Optical Fibers in Solar Plant with Cassegrain Optical System

917F0161K Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 67-70

[Article by D.S. Dyusyumbayeva and A.A. Ismailova, Kazakh Pedagogical Institute]

UDC 662.997:537.22

[Abstract] Optical fibers used for transmission of concentrated solar energy were tested with a Cassegrain system consisting of a paraboloidal concentrator 960 mm in diameter with a 66°30' embracing angle and a coaxial with it hyperboloidal counterreflector with a 30°7' convergence angle. Such a system admits longitudinal and transverse defocusing so that it becomes possible to establish the dependence of the energy distribution over the focal spot on the degree of defocusing. Optical fibers were tested for performance, the power of concentrated solar radiation being measured at both entrance and exit apertures while the input power was raised till thermal breakdown of the fiber. Prior to their thermal breakdown they were tested for heat resistance and high-temperature stability. They were found to retain both over long operating periods, owing to adequate convective and radiative heat dissipation at each end as well as to proper matching of the fiber aperture with the Cassegrain system aperture. Fibers of four different grades were tested: 4-81 (diameter 15.3 mm) 210 mm long, 6-81 (diameter 14.5 mm) 290 mm long, 8-81-3 (diameter 14.0 mm) 137 mm long, 7-81 (diameter 12.0 mm) 334 mm long. The energy density of incident solar radiation was varied over the 625-880 W/m^2 range. The power in the focal spot was measured with a calorimeter and its dependence on the energy density of incident solar radiation established on this basis. The maximum power in a focal spot 12 mm in diameter under incident solar radiation with an energy density of 738 W/m^2 was found to be 259.56 W or 2.29x10^6 W/m^2. The temperature of such a focal spot was calculated with the aid of Stefan's blackbody law and found to be approximately 2522.3 K. According to calculations, the efficiency of the solar plant under this condition was 57.6 % (based on the useful surface area of the paraboloidal concentrator) and the efficiency of the 6-81 fiber was 16.8 %. Figures 1; tables 1.

Experimental Study of $SrCl_2.8NH_3$ Desorption

917F0161M GELIOTEKHNIKA in Russian No 6, Dec 90 pp 72-75

[Article by A.Kh. Uzakov, Sh.M. Mirzayev, O.Kh. Shadyyev, and Yu.N. Yakubov, Bukhara State University]

UDC 662.997

[Abstract] An experimental study was made concerning desorption of $SrCl_2.8NH_3$ and $CaCl_2.8NH_3$ octoammines, for use of these materials in a solar refrigerator with a "hot box" radiation collector. The test apparatus consisted of a gas distributing glass manifold connected to a U-tube differential manometer and to a perforated test tube containing 3 g of octoammine under 1 MPa saturation pressure, this test tube and two stirring paddle wheels on a common shaft driven by an electric motor being inserted into a thermostat. The manifold was on the other side connected to a vacuum chamber, with one valve in the connecting tube and with another valve in one of the manometer arms. The partial pressure of ammonia was measured accurately within 2-3 %, whereupon the mass of desorbed ammonia and the number of its molecules were calculated according to the equation of state for an ideal gas. A statistical analysis of the data my the method of least squares has subsequently yielded an empirical relation describing a linear dependence of desorbed ammonia mass on the temperature in the thermostat (mean temperature of desorbed ammonia). This relation, with different numerical parameters for each octoammine, indicates that more $SrCl_2.8NH_3$ molecules are extracted and at a faster rate than $CaCl_28NH_3$ molecules at the same desorption temperature. The heat of desorption $Q = RT_1T_2(\log V_1 - \log V_2)/(T_1 - T_2)$ (R-universal gas constant, V_1, V_2- rates of ammonia desorption at temperatures T_1 and T_2 respectively, T_1,T_2-temperatures of octoammine heating at desorption rates V_1 and V_2 respectively) is lower for $SrCl_2.8NH_3$: 2.5 kJ/mole when T_1 = 368 K and T_2 = 348 K. It consequently is already desorbed at a lower temperature and the efficiency of a "hot box" will be 10-14% higher with this than with the other octoammine. Figure 3; references 2.

Method of Designing Conical Solar Concentrators

917F0161J Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 64-67

[Article by R.A. Zakhidov, Kh. Akhmedov, and Sh.I. Klychev, Tashkent Polytechnic Institute imeni A.R. Beruni, Navoi branch]

UDC 662.997:537.22

[Abstract] A solar concentrator in the form of a conic frustum with the receiver in its smaller aperture is designed, the necessary relations being established on the basis of energy balance and concentrator geometry.

Assuming that a parallel beam of solar radiation enters through the larger aperture, the radiant energy in the receiver will be $\Phi = E_0 (\pi/4)[d^2 + R(D^2 - r^2)]$ (E_0- energy density of solar radiation directly incident on the receiver, d- diameter of smaller aperture, D- diameter of larger aperture, R- reflection coefficient of tapering inside lateral mirror surface), inasmuch as solar energy reaches the smaller aperture in part by direct incidence of a cylindrical inner radiation beam (diameter is d) and in part after a number of successive reflections of a (D-d)/2 wide annular outer radiation beam by the tapering specular inside lateral frustum surface. There is a simple relation between the concentration ratio and the number of internal reflections, that number in turn depending on the opening angle and thus on the height of the frustum. These relations yield the dimensions of a conical concentrator for any specified concentration ratio when E_0, Φ, and also R are given. The relations become simpler for a coaxial receiver in the smaller aperture. Figures 3; references 5.

Estimating Radiative Heat Transfer During Simulation Tests of Solar Collectors

917F0161A Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 10-14

[Article by V.V. Moyseyenko and A.R. Fert, Scientific Research Institute of Sanitary Engineering and Construction and Building Equipment]

UDC 662.997

[Abstract] Testing solar collectors with artificial solar radiation under controllable conditions is considered, which requires an adequately accurate simulation not only of wind and ambient temperature but also of the distorting factors. A standard is therefore being developed which will take into account five such factors influencing the reliability of such tests: 1) spectral composition of incident radiation, 2) radiant flux density distribution and degree of its uniformity, 3) radiation divergence angle, 4) velocity of wind simulating air flow, 5) radiation intensity gradient between radiator surface and collector surface. Such tests are now being performed and studied at the Kiev Zonal Scientific Research Institute of Standard and Experimental Design using as solar radiation simulator a closed system of diffuse gray surfaces in the form of a right prism with square bases. It is heated by lamps, but forced cooling prevents its temperature from climbing to 400°C. Temperatures of 130-160°C have been recorded at the faces of heating lamps, at 15-30°C ambient temperatures. Taking into account the simulator design and performance characteristics, thermal radiation distorting the test results is estimated on the basis of experimental data. Tests were performed with the lamps kept on for a period of 1-2 h, sufficiently long for thermal equilibrium to have been reached. The artificial solar radiation was then measured in the plane of the solar collector with the head of an M-115M pyroanometer covering the 0.3-2.4 μm range of the spectrum and with a GSA-1M-A galvanometer as secondary instrument. The lamps were then turned off and, while the artificial solar radiation was fading out, the density of the remaining thermal radiation was measured with an ROP-1 transducer covering the 0.2-24 μm range of the spectrum and with a ShCh6800 voltmeter as secondary instrument. This procedure thus covers three successive periods of time characterized by a different set of conditions each. During the initial period, with the lamps turned on, the solar collector receives both artificial solar radiation reliably measurable with a pyroanometer and thermal radiation. Since the latter behaves differently, the sum of both cannot be reliably measured now. During the intermediate period, beginning at the instant the lamps are turned off, the intensity of artificial solar radiation drops from its prior operating level (560 W/m^2) to zero within 40-50 s and its measurement with any of the two instruments is not reliable. Thermal radiation fades out much slower, at a rate which depends on how fast the lamps are cooling down, taking a two-orders-of- magnitude longer time. During the final period there thus remains thermal radiation only and its intensity continues to drop (from 150 W/m^2 at the instant artificial solar radiation has vanished). Measurement of thermal radiation with a thermal transducer is therefore reliable during both intermediate and final periods. Figures 2; tables 3; references 12.

Heliostat on Meridional Mounting

917F0161I Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 61-64

[Article by A.V. Vartanyan and A.L. Grigoryan]

UDC 662.997:537.22(088.8)

[Abstract] A heliostat mounting is designed which ensures uniform rotation of the heliostat axis, with minimum variation of the angular velocity, and reflects solar rays in the meridional plane. The design is based on the equations of heliostat kinematics in an equatorial system of coordinates and the geometrical relations which determine the trajectory of the normal to the heliostat surface. The two trigonometric relations $\tan \nu = x_1/y_1$ and $\tan \xi = \cos \nu \, z_1/y_1$ are applied to a heliostat mounted meridionally in Yerevan (40° latitude). Angle ν is proportional to kt over the +/-60° range from t = 8 AM to t = 4 PM, the ratio ν/kt increases as δ changes from +23.4° to -23.4°. Angle ξ is independent of kt and increases as δ changes from +23.4° to -23.4°. Such a heliostat mounting simplifies the control. Figures 4; references 3.

Radiative Effects in GaAs/GaAlAs Heterojunction Solar Cells due to Combined Action of Radiant Flux and External Loads

917F0161E Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 47-49

[Article by M.Ya. Bakirov, A. Berkeliyev, R.S. Ismaylova, K. Annayev, I.A. Kabulov, R.S. Madatov, and N.

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UDC 621.362:621.385

[Abstract] An experimental study of n-GaAs/p-GaAs/p-GaAlAs solar cells was made concerning their degradation by combined action of an electron flux and a photon flux or an electron flux and an electric field. Specimens of such heterojunction variband solar cells with an about 0.5 μm thick p-GaAlAs wideband layer were produced by liquid-gaseous epitaxy from a finite volume of Ga-Al-Zn solution melt on n-GaAs substrate plates, the latter with a (100) orientation having been polished on both sides and doped with Te to electron concentrations of 9×10^{16}-3×10^{17} cm^{-3}. The p-n junction was formed by diffusion of Zn from that wideband layer 1-1.5 μm deep into the substrate. First some specimens with identical initial characteristics were only bombarded with an 5 MeV electron beam at room temperature, in the direction from GaAlAs to GaAs and thus along the electron concentration gradient in GaAs, their photoelectrical characteristics before and after this treatment being measured in a solar radiation simulator with a power density of 100 mW/cm^2. Then, while being bombarded with an electron beam, some identical specimens were also illuminated and others were placed under a d.c. voltage. In both cases the short-circuit photocurrent, the full-load power output, and the photosensitivity under any load decreased much less than as a result of electron bombardment alone. Evidently illumination during electron bombardment retards formation of radiative defects and an electric current flowing through the p-n junction so that minority carriers are injected into the base region cures point defects produced by electron bombardment. Radiative degradation was found to be inhibited more effectively by an electric field (direct current) than by illumination, neither of them however preventing the decrease of open-circuit voltage as a result of electron bombardment. Figures 1; references 5.

Cooling Capacity and Efficiency of Solar Refrigerator With Tubular Vacuumized Heat Generator

917F0161L Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 71-72

[Article by N.Ch. Dursunov. T.M. Maksudov, and D.D. Davronov, Samarkand Cooperative Institute]

UDC 662.997:537.22(088.8)

[Abstract] The cooling capacity $q_c = \xi_c q_h$ and the efficiency $\xi_c = \xi_c \xi_r$ of a solar refrigerator (ξ_c- thermal efficiency of refrigerator, q_h,ξ_r- heating capacity and efficiency of heat transferring components of heat generating solar energy receiver) are calculated on the basis of the equation of heat balance, which includes heat losses referred to unit area of the heat generating solar energy receiver. This fundamental relation is applied to a refrigerator consisting of several day-duty units and a night-duty unit, with tubes connecting the day-duty units to the upper part of a tubular vacuumized heat generator channel and the night-duty unit to its lower part. Numerical calculations based on design data pertaining to various solar refrigerators of the absorption-diffusion type and of the adsorption type yield an overall efficiency of 7.4-8.7 % under incident solar radiation with an energy density of 600-700 W/m^2 and with a 3.0 $W/(m^2.°C)$ coefficient of heat transfer from heat conducting tube and coolant, which is close to an average 7 % overall efficiency based on measurements at ambient temperatures of 25-35°C. Figures 1; references 3.

Use of Thermal Annealing for Restoration of Electrical Characteristics of Solar Batteries in Self-Contained Power Systems

917F0161G Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 53-56

[Article by G.M. Vedeneyev and V.Ye. Nikiforov, Kuybyshev Polytechnic Institute imeni V.V. Kuybyshev]

UDC 629.7.064.56

[Abstract] Recovery of solar batteries after long operation in self- contained power systems on board of spacecrafts is considered, their electrical and energy characteristics being inevitably degraded by various cosmic effects but radiative degradation being reversible so that treatment such as thermal annealing can restore them either fully or at least partly. The effectiveness of this treatment is a function of both temperature and time, the upper temperature limit being 400-450°C and the lower time limit being under 1 h. Most effective so far has been such a treatment of silicon p-n solar cells, the power necessary for annealing radiative defects having been determined experimentally. The degree of restoration will depend on both annealing temperature and time, also to some extent on the mode of operation of the solar battery and thus on the specific degrading agent such as neutron bombardment or heat load and its dose. Development of this concept is still in the experimental stage and various methods of thermal annealing are under consideration: by concentrated solar radiation, by the "hotbed" effect (U.S. Patent No 3597281 Class H01 B 1/00), and, most practically, by electric heating. Available data on Li-doped silicon solar cells indicate that by treatment with a heating power of 2 kW/m^2, the short-circuit photocurrent can be fully restored within 100 min at 150-200°C, within 1000 min at 80°C, but not at temperatures below 65°C. Several variants of a centralized power system with a device for sectional in-service restoration of the electrical characteristics of its solar battery by thermal annealing have been proposed, one utilizing the available excess power through a regulator and one using a voltage-boosting regulator. Figures 3; references 6.

Effect of Recombination in Space-Charge Region on Current-Voltage Characteristic of Silicon Solar Cells

917F0161F Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 49-53

[Article by N.M. Bogatov, Scientific-Industrial Collective "Saturn"]

UDC 621.362:621.383.5

[Abstract] The effect of recombination in the space-charge region of silicon solar cells on their current-voltage characteristic is analyzed, taking into account the diffusion mechanism of impurity distribution and the presence of a defective surface layer. Solar cells with the n^+-p-p^+ structure is considered, this structure being most widely used for commercial production. The analysis is based on the Bogatov-Zaks numerical model of semiconductor solar cells and the Shockley- Reid-Hall recombination function, taking into account that the mean life of electrons and the mean life of holes change at points near the face of the defective layer. Each mean life is resolved into two parts, one depending on the depth of the defective layer and one depending on the impurity concentration referred to the total cell volume. An additional numerical factor has been introduced to characterize the semiconductor material. Calculations were made for twenty 50 μm thick and two 200 μm thick solar cells at 300 K temperature after sparkover-initiated discharge machining, the lot consisting of four groups: 1) one without a defective layer and one with a 0.2 μm thick layer, 2) two with a 1 μm thick layer, 3) five (one 200 μm thick) with a 0.5 μm thick layer, 4) eleven (one 200 μm thick) with a 0.3 μm thick layer and one with a 0.1 μm defective layer 0.2 μm under the surface. The results indicate that the open-circuit voltage and the efficiency of such solar cells and the form factor of their current-voltage characteristic depend on the thickness and the location of the defective layer as well as on the recombination-dependent part of the mean life of electrons and of holes, this dependence being closely related to the profiles of electron and hole concentrations across the cell thickness. The volumetric recombination rate has a sharp maximum within the space-charge region, the two concentrations thus being equal at this depth. Recombination in a thin defective layer is evidently responsible for the form factor decreasing when the open-circuit increases appreciably. The wide spread of both open-circuit voltage and efficiency is attributed to poor controllability of the defective layer, namely of its thickness and recombination parameters. Figures 1; tables 1; references 10.

Method of Certification Testing Thermomagnetic Recorders of Absolute Energy Density Distribution Over Focal Spot in Solar Concentrator Systems

917F0161H Tashkent GELIOTEKHNIKA in Russian No 6, Dec 90 pp 57-61

[Article by E.A. Avanesov, M.A. Gurbanyazov, Ye.A. Podpalnyy, and D.Ya. Uvidiyev, Turkmen Institute of Agriculture]

UDC 662.997

[Abstract] The authors have developed an analytical basis for certification testing of thermomagnetic recorders of solar radiation, such instruments based on an 83Ni-17Fe element with a stripe-domain structure being used for measurement of the absolute energy density distribution over the focal spot of solar concentrators. According to this method, this distribution is measured while the intensity of directly incident solar radiation is measured at the same time. As reference gage is used a solar concentrator 1.5 m in diameter with an angular aperture of 60°, a focal length of 0.64 m, and a standard deviation of 6'. The angle through which the stripe-domain structure rotates along the 0X-axis, a function of the x-coordinate, is measured on a video display at various intensity levels of directly incident solar radiation. The theoretical part of the method involves calculating the distribution of energy density along the x-axis in the focal plane approximately by replacing the double integral with respect to the solid angle with the sum of integrals and then evaluating the sum of values of the integrand function with certain weight factors, determination of the components of this function being included in the subprogram for tracking a light ray on its return stroke. The luminance of radiation incident on a point of the receiver at some angle is calculated on the basis of its linear dependence on the luminance of the visible solar disk, with the specular reflection coefficient as proportionality factor. Another multiplier is added to account for vignetting when the concentrator is oriented toward the solar disk, the luminance of incident radiation being zero beyond the maximum angle of incidence. A correction factor accounting for roughness of real concentrator surfaces is also entered into that subprogram. Results of theoretical calculations including a statistical analysis have been checked against the results of experimental measurements with the angular aperture as variable parameter, two concentrators with angular apertures of 46° and 32° respectively having been tested with a thus calibrated thermomagnetic recorder. Figures 3; references 8.

Prospects for Development of the Bearing Industry

917F0141A Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 1-2

[Article by Yu.I. Bubnov]

UDC 621.822.6.002"313"

[Text] The bearing industry occupies an exceptional position in commercial manufacturing because without its product, i.e., rolling bearings, not one type of technology could function. This is precisely why the domestic bearing industry was essentially the first to implement the country's industrialization plans and to quickly develop them further.

All of the stages of its development were determined by real needs. Thus, rail transport's transition in recent years from slide bearings to rolling bearings required organization of the respective industry and, later, its specialization.

The start-up of planned facilities at the No. 16 State Bearing Plant [GPZ-16] to produce bearings for rail transport is currently being completed. The construction of the Volga Automotive Plant [VAZ] made it necessary to create such large bearing plants as the GPZ-15 (in Volzhsk) and the GPZ-23 (in Vologda). KamAZ trucks have necessitated not only an increase in the production capacities of existing bearing plants but also the construction of a new plant, the GPZ-28 in Lutsk.

The bearing industry's manufacturing base consists of 30 state bearing plants. Four of them are in the construction stage, seven are bearing reconditioning plants, and two are pilot plants. This base produces more than 1 billion bearings that meet the national economy's main demands.

Development of the bearing subsector is continuing, however. By 1995, for example, it should produce no fewer than 1,185 million bearings yearly, and by the year 2000 it should produce at least 1,350 million.

Meeting such a production program requires redesigning and retooling enterprises. Design developments sketching the bearing industry's development show that there is no way around new plants. Three will appear by 1995: the GPZ-19 (in Shavat), the GPZ-26 (in Markhamat), and the GPZ-30 (an affiliate of the GPZ-9 Production Association in Leninsk in the UzSSR. If one counts the GPZ-27 in Akhunbabayev, which is now being built and slated to start manufacturing bearings, then four new plants will have been built by 1995. All of them are in the Central Asia region, however, where the demographic situation is very conducive to the creation of new commercial industries—and even demands it.

The GPZ-19 is slated to produce instrument bearings. Roller bearings with short cylindrical rollers and radial single-row ball bearings in a size range up to 85 mm are slated for production at the GPZ-26, and especially large (up to 2,000 mm in diameter) two-row spherical roller bearings are slated for production at the GPZ-30.

The expansion of automobile production at the new plant in Yelabuga and the increase in production facilities at existing automotive plants have made it necessary to increase the output of bearings at the GPZ-18, GPZ-23, GPZ-27, GPZ-28 (after its construction, which has already been begun, has been completed), GPZ-3, GPZ-4, GPZ-8, GPZ-11, GPZ-15, and GPZ-20 (after redesign and retooling).

The bearing industry should, moreover, be quickly prepared to meet the growing demand for bearings for industries involved in manufacturing consumer goods. (This includes industries in sectors that are undergoing conversion.) Such goods require mainly small bearings, i.e., instrument-type and single-row ball bearings in the size range up to 56 mm. This is precisely why the development of plants manufacturing these bearings (the GPZ-4, GPZ-5, GPZ-13, GPZ-20, and GPZ-24) are being reinforced by the start-up of a new plant in Shavat.

The needs of the machine tool building industry for precision bearings will be met by retooling the GPZ-1, GPZ-3, GPZ-4, GPZ-9, GPZ-20, and GPZ-23.

Against the overall background of diverse problems that will need to be solved in the near future, the following are especially attention worthy: creation at the GPZ-1 of ultralarge (up to 7,000 mm in diameter, which is unprecedented for our industry) bearings for offshore drilling rigs and large bearing and turning devices for use in construction machinery; mass production (at the GPZ-24 and GPZ-29) of ultraprecision instrument bearings for video and computer technology; and mass production (at the GPZ-4, GPZ-23, and GPZ-24) of extra-low-noise bearings. Without these, further successful development of the priority sectors of the machine building complex will be impossible. And because this complex is the base for our entire national economy, it is understood that these unique types of bearing production must be created in the shortest time periods possible. And this is where we need foreign partners.

Thus, the ultralarge bearings will be manufactured by license from the firm Rote Erde (the FRG), and the world's best firms such as, for example, FAG (the FRG) and NMB (Japan) will be involved in the manufacture of the ultraprecision bearings. A joint Soviet-Yugoslav enterprise created on the basis of the GPZ-24 (to be constructed by the Yugoslav planning and construction firm Smelt) will begin manufacturing extra-low-noise bearings for the electrical engineering industry.

A gradual intensification of the specialization of bearing plants is slated during the course of redesign and retooling. The production of cardan bearings will, for example, be concentrated at the GPZ-3 after the introduction of a new manufacturing process that was purchased from the firm INA in the FRG. This means that

in the future, obsolete technology will be withdrawn from such plants as the GPZ-1, GPZ-10, GPZ-11, GPZ-24, and GPZ-28.

The GPZ-3 and GPZ-8 will cease manufacturing bearings for railroad transport because, as has already been mentioned, their manufacture will be concentrated at the GPZ-16. Redistributing part of the line of conical roller bearings between the GPZ-9 and GPZ-28 promises to provide great benefits: creating a shop to produce small-series bearings at the GPZ-28 and switching the production of bearings with an outer diameter of up to 500 mm from the GPZ-9 to the GPZ-28 will make it possible for the GPZ-9 to sharply increase its output of ultralarge bearings (up to 2,000 mm in diameter), which are in especially short supply.

Specialization of these and other plants will provide a significant reserve for increasing the efficiency of bearing production. And sectorial science, particularly the All-Union Scientific Research, Planning and Design Institute of the Bearing Industry [VNIPP], will begin to play an ever-increasing role in this matter. The classification system that has been proposed by its specialists will, for example, become the basis for specialization; the classification includes 155 technological-design groups and subgroups, i.e., arrays that are linked by similarities in their design and in the technology used to manufacture them. In the ideal, the highest level of specialization may be the case where a plant manufactures bearings belonging to just one technological-design group. (Examples of such a plant are the GPZ-16 and the GPZ-19, which is under construction).

Specialists at the Podshipnik [bearing] State Production Association are, however, proceeding not only from the ideal but more from reality. They therefore feel that achieving such a level of specialization for all plants is still not foreseeable: it would require that the country have a minimum of 155 plants (the number of technological-design groups). Although such advanced bearing industries as that in the United States produce the same number of bearings that our plants do, they already have 140 individual plants belonging to 83 firms. As was mentioned above, our country has only 39 bearing plants, including pilot and reconditioning plants. That means that our bearing industry is still at a low level of production specialization. The plants that are the most lagging in this respect are the GPZ-1 (67 technological-design groups), the GPZ-4 (49 subgroups), the GPZ-3 (41 subgroups), and the GPZ-11 (29 subgroups).

It is clear that the low level of specialization is greatly complicating production management. Easing the situation of these plants even somewhat requires, first, disseminating their product line among other plants and, second, providing for in-plant specialization during redesign and retooling. And this is what has been done lately.

Thus, the GPZ-4 has moved its thermal and lathe operations and warehouses for metal and other materials to the suburbs, and the GPZ-3 has created its own affiliate (the GPZ-22 in Gagestanskiye Ogni), which will assume responsibility for the manufacture of small hinged bearings.

The GPZ-1 has turned out to be in a very unfavorable position. Despite the fact that it has been freed from producing seven subgroups of bearings, it will be the site at which the new ultralarge bearings will be created. This will give it 14 additional technological-design subgroups. True, production facilities in a separate territory (the Lyublino rayon in Moscow) are being built and outfitted for this purpose, and this will essentially create the prerequisite for splitting off this territory into a separate enterprise.

Despite the expansion of production inside the country, the task of fully meeting all of the national economy's needs for rolling bearings cannot be achieved in isolation from the world market. An understanding of this has already resulted in an expansion of the ties between the country's national economy and the world economy and world market. It has also results in a gradual increase in the amounts of purchases and in the list of equipment furnished with foreign bearings. This naturally necessitates spare parts. And two routes may be taken here: either launching their production (duplicating the product list) at our plants or else purchasing them from abroad. The first route is unacceptable, if only because it would sharply reduce the level of specialization at our plants and require a great deal of new equipment, etc. The second route remains, i.e., purchase some portion of the bearings with currency obtained from the sale of our own bearings. But doing this requires transforming domestic bearings into a product that is competitive on the world market and doing it in such a way that our bearings would, provided the price were identical, be no less in demand than bearings manufactured in the United States, FRG, and other industrially developed countries. This is a very complicated task, but it can be done.

Rolling Bearings for Front-Wheel Drive Automobiles

917F0141B Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 7-11

[Article by V.A. Kuzmin and S.A. Kulagin]

UDC 629.114.6:233.2

[Text] New families of front-wheel drive automobiles have been thought up that are more comfortable and have improved technical and economic characteristics. In view of this, the bearing industry has been charged with the task of creating bearings that not only guarantee (as is always required) that a vehicle will have a specified

useful life but that will also meet a number of additional requirements with respect to operating noise, specific consumption of metal, and high degree of standardization.

The industry has solved the problem: it has developed 35 new type sizes of bearings. Included among them are special designs intended for specific automotive subassemblies and that allow for the specifics of their assembly.

Figures 1, 2, and 3 respectively diagram the arrangement of bearings in the VAZ-2108 (VAZ-2109), AZLK-2141, and ZAZ-1102 automobiles and their modifications. Figure 4 and Tables 1, 2, and 3 present the design diagrams and main technical characteristics of the bearings themselves.

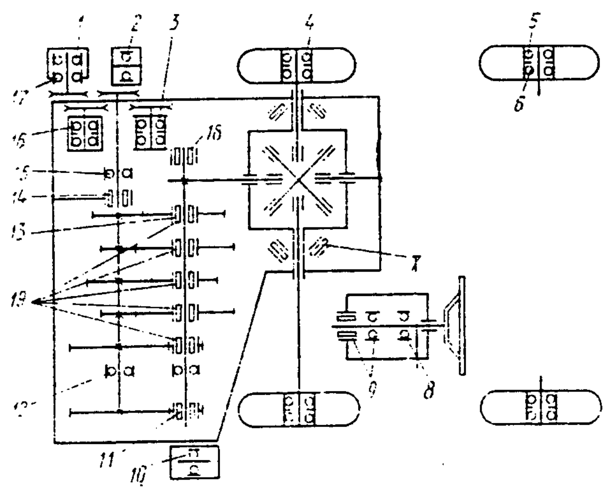

Figure 1.

We will examine several of these bearings.

Figure 4a depicts a water pump bearing. It is a ball, radial, double-row bearing with a bilateral seal and plastic retainer. Lubricant (plastic) is placed in it at the bearing plant and is neither changed nor replenished during the process of its operation. But this is only in the case where there is no leakage of coolant. The appearance of a leak means that the fluid has reached the bearing's rubber reinforced seal and destroyed it. It is therefore necessary that, during operation, the gland seal be replaced at the first signs of leakage through the water pump seal; otherwise, the bearing will also be quickly ruined. (When replacing a gland seal it is important to remember to transmit the force only through the shaft when pressing the blade and pulley to the bearing shaft.)

Clutch bearings (Figure 4b) are ball, radial bearings with two protective washers and plastic retainers. Lubricant calculated to be sufficient for the bearing's entire operating life is also placed in these.

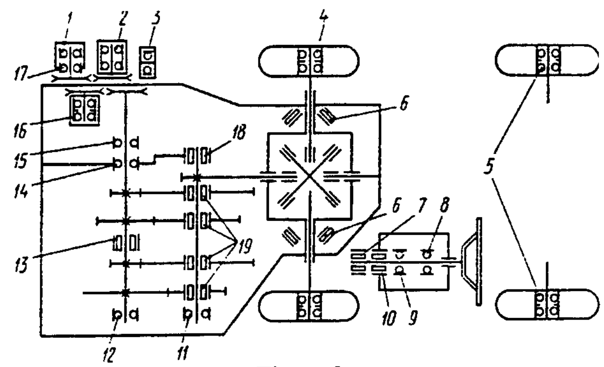

Figure 2.

Roller (Figures 4d, 4g, 4p, 4t, 4w, and 4y) and ball (Figures 4h, 4o, 4q, and 4s) bearings with an increased load-carrying capacity and plastic retainers are installed in gear boxes. In addition, ball, radial-thrust, single- and double-row bearings with a split inner ring and plastic retainers are used in the subassemblies of AZLK-2141 and ZAZ-1102 automobiles. Because they have comparatively small overall dimensions, they withstand significant axial loads and maintain specified small axial clearances. Needle bearings without rings but with plastic retainers (Figures 4d and 4p) are installed to reduce the specific consumption of metal in pinion supports.

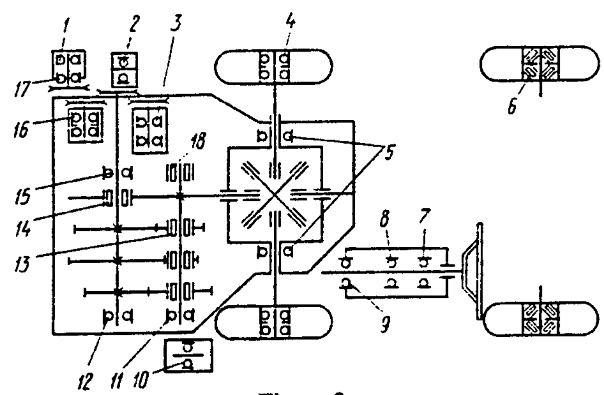

Figure 3.

Needle bearings with a new design, i.e., bracelet-type (split) needle bearings with plastic retainers, which significantly reduce the operating noise of automobile subassemblies, are used to guarantee good assembly of subassemblies on multidiameter shafts.

As is known, a front-wheel drive imposes special requirements regarding hub bearings. And it has been possible to meet these requirements: Instead of the two conical bearings in each wheel support that are conventionally used in front-wheel drive vehicles, one ball bearing is mounted in each. Besides everything else, this significantly reduces the specific consumption of metal

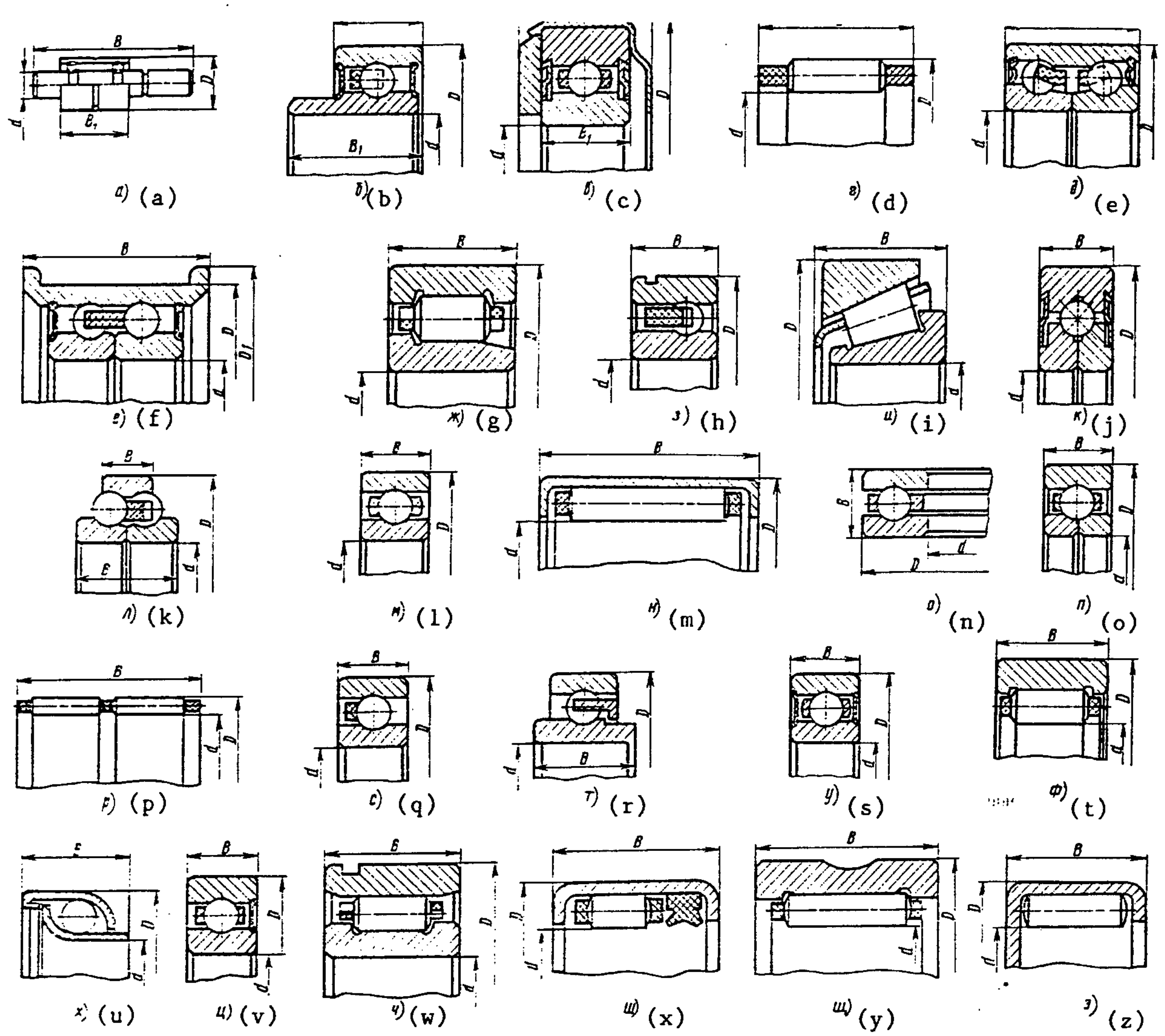

Figure 4.

required for the subassembly. The new bearings (Figure 4e) have bilateral seals and, what is more, do not require control of their axial clearance (which largely determines the duration of their service) during operation.

New ball and roller bearings with stamped outer rings and plastic retainers (Figures 4m and 4x) that do not need to be serviced during their operation are also used in a fundamentally new steering mechanism subassembly.

Table 1.

Position on		Installation Site	Convention	Bearing Type	Dimensions, mm			No. per Automobile	Use in Other Vehicles
Fig. 1	Fig. 4				d	D/D_1	B/B_1		
1	s	Rear support of generator shaft	6-180201U1S9	Ball, radial, single-row, with bilateral seal, stiffened requirements regarding vibration level	12	32	10	1	All VAZ models, ZAZ-1102
2	r	Ignition distributor	7690906	Ball, radial, single-row	30	47	6	1	All VAZ models, AZLK-2141, ZAZ-1102
3	f	Gas distribution drive mechanism	6-256705Ye1S9	Ball, radial-thrust, double-row, with plastic retainer and bilateral seal, flanges on outer ring	25	55/62	28	1	VAZ-2105, VAZ-2107, VAZ-1111, AZLK-2141
4	e	Front wheel hubs	6-256907Ye1S17	Ball, radial-thrust, double-row, split, with bilateral seal and plastic retainer	34	64	37	2	AZLK-2141, ZAZ-1102
5	i	Differential	6U-7207A	Roller, conical, single-row with stiffened tolerance for assembly height, increased load-carrying capacity	35	72	18.5	2	AZLK-2140
6	e	Rear wheel hubs	6-256706Ye1S17	Ball, radial-thrust, double-row, split, with bilateral seal, with plastic retainer	30	60	37	2	-
7	l	Steering wheel shaft support	1000805	Ball, radial, single-row	25	37	7	2	AZLK-2141
8	q	Upper support of steering mechanism pinion	80-903Ye	Ball, radial, single-row, with plastic retainer	17.7	35	8	1	-
9	m	Lower support of steering mechanism pinion	604901YeUS17	Roller, needle, with outer stamped ring and plastic retainer, increased precision	11.11	17.46	13	1	-
10	j	Upper support of front suspension's frame	348702S23	Ball, radial-thrust, single-row, with split inner ring and two protective washers, without retainer	12	52	14	2	-
12	h	Rear supports of primary and secondary gear box shafts	6-50305A1Ye	Ball, radial, single-row, with shifted center of ring channels, increased load-carrying capacity, with plastic retainer	25	62	17	1	-
11, 13, 19	d	Pins of 1st, 2d, 3d, 4th, and 5th gears of secondary gear box shaft	464706Ye1	Roller, radial, needle, without rings, with bracelet type plastic retainer	32	37	27	5	-
14	g	Front support of primary gear box shaft	66-42205AYe	Roller, radial with short cylindrical rollers, plastic retainer, increased load-carrying capacity	25	52	15	1	ZAZ-1102
15	c	Series version of clutch	360106KS23	Ball, radial, single-row, with two protective washers, detachable ring, in case	30	55	13/ 19.7	1	-
15	b	Prospective version of clutch	6-520806YeS23	Ball, radial, single-row with two protective washers, protruding inner ring, plastic retainer	31	55	13/19	1	VAZ-1111, ZAZ-1102

Table 1. (Continued)

Position on		Installation Site	Convention	Bearing Type	Dimensions, mm			No. per Automobile	Use in Other Vehicles
Fig. 1	Fig. 4				d	D/D_1	B/B_1		
16	a	Cooling system's water pump	6-330802YeS17	Ball, radial, double-row with roller instead of inner ring, bilateral seal, plastic retainer	16	30	92/39	1	ZAZ-1102
17	s	Front support of generator shaft	6-180302U1S9	Ball, radial, single-row with bilateral seal, stiffened requirements regarding vibration level	15	42	13	1	All VAZ models, ZAZ-1102
18	g	Front support of gear box's secondary shaft	66-42305AYe	Roller, radial, single-row with short cylindrical rollers, plastic retainer, increased load-carrying capacity	25	62	17	1	-
-	n	Jack	8903	Roller, thrust	17.5	30	8.969	1	All VAZ models, ZAZ-1102

Table 2.

Position on		Installation Site	Convention	Bearing Type	Dimensions, mm			No. per Automobile	Use in Other Vehicles
Fig. 2	Fig. 4				d	D/D_1	B/B_1		
1	s	Front support of generator shaft	6-180502K1S9Sh1	Ball, radial, single-row, with bilateral seal	15	35	15	1	AZLK-2141, GAZ-24
2	a	Cooling system's water pump (2106-70 motor)	6-330902S17	Ball, radial, double-row, with bilateral seal	16	30	115/39	1	VAZ-2101, VAZ-2103, VAZ-2106, VAZ-2107
3	r	Ignition distributor	7690906	Ball, radial, single-row	30	47	7	1	All VAZ models, ZAZ-1102
4	e	Front wheel hubs	6-256908Ye2S17	Ball, radial-thrust, double-row, with bilateral seal and plastic retainer	37	72	37	2	-
5	e	Rear wheel hubs	6-256907Ye1S17	Roller, radial-thrust, double-row, with bilateral seal and plastic retainer	34	64	37	2	VAZ-2108, VAZ-2109
6	i	Differential	6-2007108A	Roller, conical, single-row	40	68	19	2	-
7	z	Cardan shaft of steering system	904900	Roller, needle, with one outer stamped ring	10	16	10.45	8	VAZ-2101, VAZ-2103, VAZ-2105, VAZ-2106, VAZ-2107, VAZ-1111
8	1	Steering column	1000805	Ball, radial, single-row	25	37	7	1	VAZ-2108, VAZ-2109, VAZ-2105, VAZ-1111
9	x	Rear support of steering mechanism	604703Ye	Roller, needle, without inner ring, with unilateral seal and plastic retainer	17	23	15	1	-
10	1	Front support of steering mechanism	101	Roller, radial, single-row	12	28	8	1	-

Table 2. (Continued)

Position on		Installation Site	Convention	Bearing Type	Dimensions, mm			No. per Automobile	Use in Other Vehicles
Fig. 2	Fig. 4				d	D/D_1	B/B_1		
11	k	Rear support of main transmission shaft	6-866706Ye1	Ball, radial-thrust, with split inner ring and plastic retainer	28	72	16/27	1	-
12	o	Rear support of central gear box shaft	6-126805Ye	Ball, radial-thrust, single-row, with plastic retainer	25	62	17	1	ZAZ-1102
13	y	Central support of primary gear box shaft	6-254705Ye	Roller, radial, with long cylindrical rollers, without inner ring	25	37	17	1	-
14	s	Front support of primary gear box shaft	6-180502K1US9	Ball, radial, single-row, with bilateral seal	15	35	14	1	VAZ-2101, VAZ-2103, VAZ-2106, VAZ-2107
15	b	Clutch	6-520907Ye3S23	Ball, radial, single-row, with two protective washers and plastic retainer	37	62	21/14	1	-
16	f	Gas distribution drive mechanism	6-256705Ye1S9	Ball, radial-thrust, double-row, with plastic retainer, bilateral seal, flanges on outer ring	25	55/62	28	1	VAZ-2105, VAZ-2108, VAZ-1111
17	s	Rear support of generator shaft	6-180603KS9Sh1	Ball, radial, single-row, with bilateral seal	15	35	15	1	AZLK-2141, GAZ-24
18	w	Front support of main transmission shaft	6-322209Ye2U	Roller, radial, single-row, with plastic retainer	45	85	19	1	-
19	d	Pins of 1st, 2d, 3d, and 4th gears	464907Ye1	Roller, needle, single-row, with plastic split retainer	37	42	22	4	-

Table 3.

Position on		Installation Site	Convention	Bearing Type	Dimensions, mm			No. per Automobile	Use in Other Vehicles
Fig. 3	Fig. 4				d	D	B		
1	s	Front support of generator shaft	6-180302U1S9	Ball, radial, single-row with bilateral seal, stiffened requirements regarding vibration level	15	42	13	1	All VAZ models
2	r	Ignition distributor	7690906	Ball, radial, single-row	30	47	7	1	All VAZ models, AZLK-2141
3	v	Tightening roller of toothed engine belt	6-160202Ye	Ball, radial, single-row, with unilateral seal and plastic retainer	15	35	11	2	-
4	e	Front wheel hubs	6-256907Ye1S17	Ball, radial-thrust, double-row, split, with bilateral seal and plastic retainer	34	64	37	2	VAZ-2108, VAZ-2109, AZLK-2141
5	i	Rear wheel hubs (outer)	6-137205A	Roller, conical, increased load-carrying capacity	25	52	10.25	1	-
6	i	Rear wheel hubs (inner)	6-7204A	Ball, conical, increased load-carrying capacity	20	47	15.25	1	-

Table 3. (Continued)

Position on		Installation Site	Convention	Bearing Type	Dimensions, mm			No. per Automobile	Use in Other Vehicles
Fig. 3	Fig. 4				d	D	B		
7	q	Differential	6-207Ye1	Ball, radial, single-row, with plastic retainer	35	72	17	2	-
8	u	Steering support	96904S17	Ball, radial-thrust, single-row, with stamped outer ring and lock ring, without retainer	19	32	15	1	-
9	1	Steering mechanism	7000102	Ball, radial, single-row	15	32	8	2	-
10	j	Upper support of front suspension's frame	348702S23	Ball, radial-thrust, single-row, with split inner ring and two protective washers, without retainer	12	52	14	2	VAZ-2108, VAZ-2109
11	q	Rear support of secondary gear box shaft	6-305Ye1	Ball, radial, single-row, with plastic retainer	25	62	17	1	-
12	o	Rear support of primary gear box shaft	6-126805Ye	Ball, radial-thrust, single-row, with split inner ring and plastic retainer	25	62	17	1	AZLK-2141
13	p	Pin of 1st gear of secondary gear box shaft	664906Ye	Roller, needle, double-row, without rings, with plastic retainer	28	33	27	1	-
14	g	Front support of primary gear box shaft	66-42205AYe	Roller, radial, with short cylindrical rollers, plastic retainer, and increased load-carrying capacity	25	62	17	1	AZLK-2141
15	b	Clutch	6-520806YeS23	Ball, radial, single-row, with two protective washers, protruding inner ring, and plastic retainer	31	52	15	1	VAZ-2108, VAZ-2109
16	a	Cooling system's water pump	6-330802YeS17	Ball, radial, double-row, with shaft instead of inner ring, bilateral seal, plastic retainer	16	30	92	1	VAZ-2108, VAZ-2109
17	s	Rear support of generator shaft	6-180201U1S9	Ball, radial, single-row, with bilateral seal, stiffened requirements regarding vibration level	12	32	10	1	All VAZ models
18	t	Front support of secondary gear box shaft	6-292305AYe	Roller, radial, single-row, with short cylindrical rollers, plastic retainer, without inner ring, increased load-carrying capacity	35	62	17	1	-
19	f	Pins of 2d and 3d gears of secondary gear box shaft	464906Ye	Roller, needle, single-row, without rings, with plastic retainer	32	37	13	4	-
-	n	Jack	8903	Ball, thrust	17.5	30	8.969	1	All VAZ models

Special ball radial-thrust bearings with flanges on the outer ring (Figure 4f) were developed for the engine's gas distribution drive mechanism. They have bilateral seals, and the lubricant is applied when the bearing is assembled.

The possibility of standardization was given consideration during the process of developing the new bearings for the entire family. As a result, one and the same types of bearings are used in the individual subassemblies. Thus, the cooling system pump bearings of the engines of VAZ-2108 automobiles are also installed in the pumps of AZLK-2141 and ZAZ-1102 automobiles, and the hub bearings used in the front wheels of VAZ-2108 automobiles are also used in the hubs of the rear wheels of AZLK automobiles. Bearings from previously manufactured models are also used in front-wheel drive automobiles.

As tests and operating experience have shown, all of the new bearings are capable of guaranteeing reliable operation of bearing subassemblies when, of course, the rules regarding their assembly and timely monitoring of the condition of the subassemblies are followed. Specifically, it must be borne in mind that most of the new bearings are of the "closed type with a bilateral seal" and are thus not lubricated during the process of their use. And such bearings are very sensitive to handling. In no case, for example, should they be washed in gasoline or other fluids under the assumption that they will still be of service after such washing. This goes without exception. A malfunctioning bearing can only be replaced.

Rotary Lines—In-House Developments

917F0141J Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 26-28

[Article by A.A. Kalchenko and A.G. Blazhnov]

UDC 621.822.6.002.2:658.527.011.56:62-133

[Text] The first rotary lines in the bearing industry appeared nearly 15 years ago. And the No. 3 State Bearing Plant [GPZ-3] was the first to introduce them; the plant uses them to manufacture needle bearings,i.e., precisely those bearings that have enjoyed a steady increase in demand that will not be possible to satisfy without a radical change in technology, specifically in the technology of process automation.

The first rotary line [LKP-1] was intended to manufacture 942/8 needle bearing rings, and it performed five operations. It had a capacity of 160 units per minute. The second line was the LKP-2. Together with the LKP-1 it formed a single line for stamping 942/8 rings and performed 10 operations. It is interesting to note that, like the LKP-1, the LKP-2 was capable of realignment for five type sizes of bearing rings that were close from an overall dimension standpoint and deformation conditions and identical from a manufacturing process standpoint. In other words, they already contained elements of flexibility even though the concept did not yet exist.

The next step was a plan for three lines (LKP-3, LKP-4, and LKP-5) that encompassed the entire manufacturing cycle entailed in stamping bearing rings with larger dimensions (943/20, 942/20, and 941/20). Figure 1 shows how they operated. It presents a process flow of the machining of a 943/20 outer bearing ring. The GPZ-3 currently has 20 automated lines in operation. They are manufacturing more than 18 million bearing rings annually.

In addition to rotary lines for manufacturing rings and needles, the equipment set at the GPZ-3 includes automatic machines to chop and perform the preliminary draw-forming of blanks; thermal lines (MLT-2) for the operations of etching, cleaning, and drying; automatic machines for circular chopping of needle roller blanks; automatic machines to assemble the bearings, etc. All of this made it possible to provide a high technical level of manufacturing, integrate automation of the processes entailed in manufacturing all of the most massive series of needle bearings, triple their production volume without increasing the number of workers or manufacturing areas, and improve labor conditions and industrial culture.

The plant's experience demonstrated the following: automated rotary lines hold enormous reserves for increasing labor productivity. During a single shift, for example, two lines (the LKP-7 and LKP-8) can produce 10 million 904900 bearing rings a year, i.e., the same amount as could be produced by 30 press operators using the old manufacturing process. And they are serviced by just two individuals. The plant's entire system of automated equipment to produce needle bearings has eliminated about 100 workstations, and these were the least prestigious, i.e., those associated with manual, monotonous, fatiguing labor. Forty of the workers were given the opportunity of working under better conditions.

Despite the fact that rotary lines possess indisputable advantages (such as high capacity, stability of the manufacturing process, high quality of the product produced) over other conventional machines, the GPZ-3 still

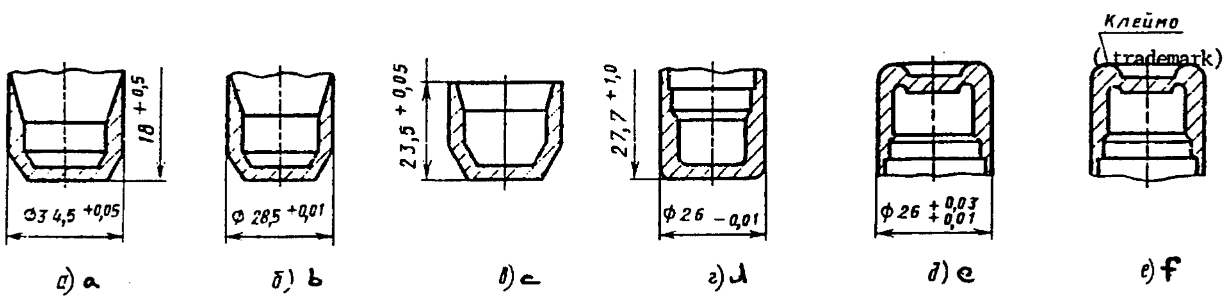

Figure 1. Process Flow of the Machining of the Outer Ring of a 943/20 Bearing: a. blank; b. secondary draw-forming; c. facing; d. final draw-forming; e. calibration; f. applying the trademark

remained the only bearing industry enterprise to have introduced them all the way until 1986, at which time a special government decision was reached on the matter. Since that time the picture has changed. Design groups dealing with rotary machines were immediately created at all of the large bearing plants, and the design office in charge of development and introduction of rotary lines at the All-Union Scientific Research, Planning and Design Institute of the Bearing Industry Scientific Production Association was placed in charge of coordinating work in the area of using and introducing them. A long-term program was developed for using rotary lines; its main idea was to create computer-integrated manufacturing based on rotary lines that would enable the mass production of bearings. Its implementation should, moreover, free thousands of workers and provide a savings amounting to tens of millions of rubles.

The program is being implemented. The data presented in Table 1 are proof of this.

Table 1.

Status	By Year				Total	
	1986	1987	1988	1989	Planned	Actual
Manufactured	2	16	13	21	39	52
Introduced	2	13	7	12	18	34

As is known, rolling bearings are the product produced in the greatest quantity by the machine building sector. There are about 200 type sizes with a yearly production program exceeding 500 million units and, consequently, several billion completing components. But there is still a shortage of bearings produced.

In view of the problems with capital investments, the problem will not be solved without rotary technology. This is because only rotary lines provide the capability of increasing the output of certain bearing design groups that are in short supply (needle, cardan, bicycle, etc.) without expanding existing production. Hence the direction of the work being done by technological-design organizations. The same can be said of the All-Union Scientific Research Institute of the Bearing Industry. There, for example, a computer-aided system to manufacture, assemble, rustproof, and package 876901 bicycle bearings recently passed tests. It has a capacity of 45,000 pieces per hour.

The system consists of two rotary lines - The RLSP-1 and RLKP-1.

The first line has four basic rotors that perform the operations of bending, preliminary bending, final bending, and assembling the bearings. (One of the rotors is shown in Figure 2. It is the rotor for manufacturing retainers. Rams (2) that are driven by fixed tracers (3) and that are coaxial with the tool blocks (1) serve as its actuators. In the axial direction the rams are connected with the tool blocks that perform the shaping operations.)

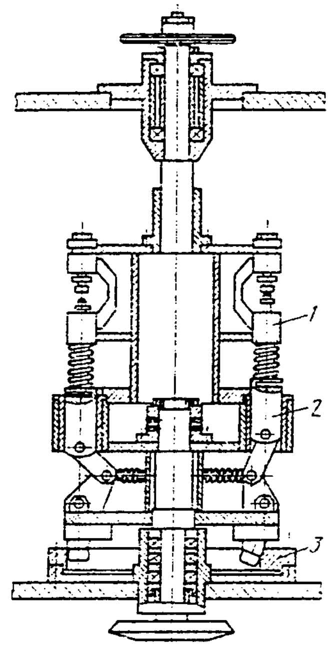

Figure 2. Process Rotor

The second line packages the bearings. It rustproofs them, stacks them (12 pieces in a stack), and packages them in paper.

Both lines have an individual loading system and, when necessary, can operate autonomously.

The All-Union Scientific Research, Planning and Design Institute of the Bearing Industry is now updating its lines for 876902, 876903, and 876705 bearings. The first steps are being taken to create high-capacity (7 to 8 bearings per hour) rotary lines to manufacture series 876000 bearings.

In our country and in other countries as well there has been a sharp increase in the production of ball radial-thrust bearings with stamped rings (in the United States, for example, 160 million of them are produced, whereas we produce 150 million units). This is explained by their comparatively low price and suitability for many machine building sectors, where they require particular precision.

The All-Union Scientific Research, Planning and Design Institute of the Bearing Industry is developing a technology to manufacture an array of such bearings (Figure 3) that can be used with rotary technology. Specifically, there are plans to create an equipment system in 1994. One of these sets will provide a yearly savings of 7 million rubles.

There are also plans for joint development (with the Rotor Interbranch Scientific-Technical Complex) of integrated manufacturing of improved cardan bearings

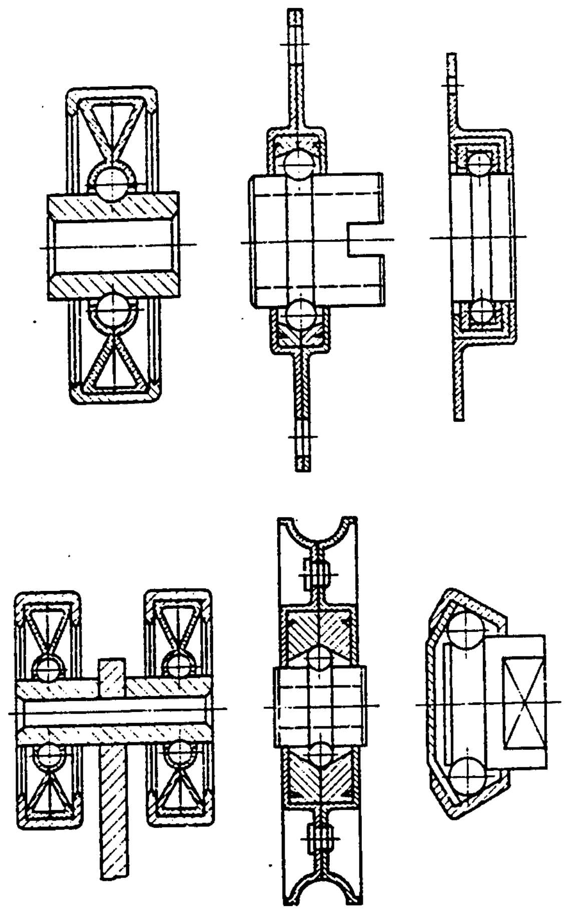

Figure 3. Designs of Bearings With Stamped Rings

manufactured from steel strip and intended for automotive and agricultural machine building. It is anticipated that introducing one such system will result in a savings of no less than 13 million rubles.

Several types of rotary machines are being created for bearing assembly operations.

At the GPZ-8, for example, an original rotary line to assemble ball bearings at a rate of 100 pieces per minute will soon be started up. The line selects sets of rings, completes them, brings the balls up to speed, applies half-retainers, and glues them. The GPZ-4 is producing the GUR-10P rotary and GUR-5P automatic rotary machines to package ball bearings and RLKP-100 (Figure 4) high-capacity rotary machines to wash the rings and assembled bearings. The cleaning is performed in two zones—stream and ultrasonic. The rings pass from a loading chute (1) to a stream cleaning chamber (2). Next, they are moved automatically to an ultrasonic cleaning chamber (3). After passing through it, they are unloaded to chutes (4).

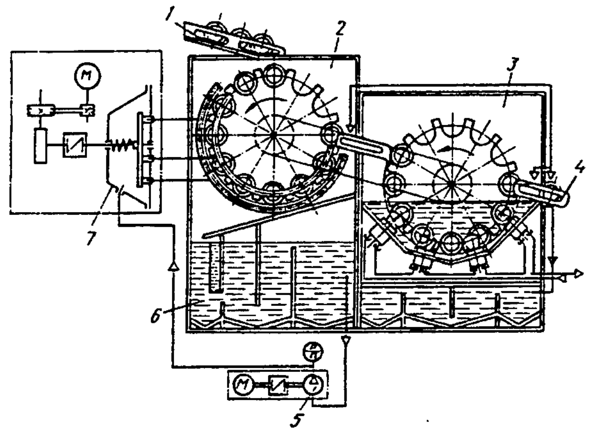

Figure 4. Diagram of an RLPK-100 Rotary Line for Cleaning Rings

To increase the effect of the stream cleaning, an interrupter (7) that creates an interrupted stream has been included in the detergent feed system, which consists of a tank (5) and pump (6). The rings are blown with compressed air when they pass from one zone to another and when they pass from the ultrasonic cleaning chamber.

The RLKP-100 has a capacity of 100 pieces per minute.

Table 2.

Purpose of line	No. Required Types and Models	No. Lines Needed by Subsector
Rolling rings	15	130
Turning and finishing operations	10	70
Assembling the bearings	17	190
Quality control (applying lubricant, inspecting the radial gap and vibration level, etc.)	26	100
Washing the rings and assembled bearings	10	130
Corrosion-proofing and packaging	12	90
Stamping:		
balls	6	10
rollers	3	15
bearing rings	7	30
bearings' retainers	6	100
Electromechanical branding	10	150
Manufacturing plastic retainers	5	15
Phosphate coating the ring blanks	2	20
High-quality annealing of the ring edges	5	20
Assembling the retainer units	2	20

As has already been noted, rotary lines may be used in virtually any of the processes entailed in manufacturing

bearings. The demand for such lines is therefore growing constantly. Table 2 is proof of this. It presents data regarding the need of plants in the subsector for such rotary lines (the table only includes announced needs). It is evident that the plants need lines intended for the most diverse purposes (to meet these needs the plants must produce 136 types and models of rotary lines) in rather large quantity (about 1,110). Of course this is a great deal. In view of the fact that rotary lines are comparatively simple, however, the task of providing them is completely achievable.

Modern Bearing Steels

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[Article by A.G. Kurilov and O.A. Popov, candidates of technical sciences]

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[Text] the use of high-quality materials to manufacture rings and rollers is one of the main conditions of achieving bearings that have a high reliability and long life. And then there is the savings of the materials themselves: the higher the quality of the starting materials, the more fully design and technological decisions can be realized while still reducing the bearing's mass. This is precisely why the program to increase the efficiency of bearing production at the enterprises of such firms as SKF (Sweden) and Timken (United States) are beginning with measures to increase the quality of the metal.

Our bearing subsector is currently using more than 100 grades of steels and alloys to produce bearing components. Thus, the possibilities here are also extensive. The first of these is to reduce the contamination of the steels by nonmetal inclusions. The problem is that under the intensive effect of local cyclic loads, nonmetallic inclusions in metal become foci of spalling and thus determine the level of a bearing's life. Oxide nonmetal inclusions pose the greatest threat. Therefore, the manufacturers of special steels are continuing to apply their efforts to reducing the amount of oxygen in steel to 6-10 ppm (Figure 1).

The domestic and foreign experience confirms that vacuum degassing is one way of reducing the oxygen content in bearing steel. It is widely used, for example, at many of the leading foreign firms: SKF (Sweden), Timken (United States), and Sanyo Steel and Aichi Steel (Japan). These firms have high-capacity units that use degassing, electromagnetic stirring, and protection of the metal stream during pouring. All of these measures make it possible to raise the quality of electric furnace steel to

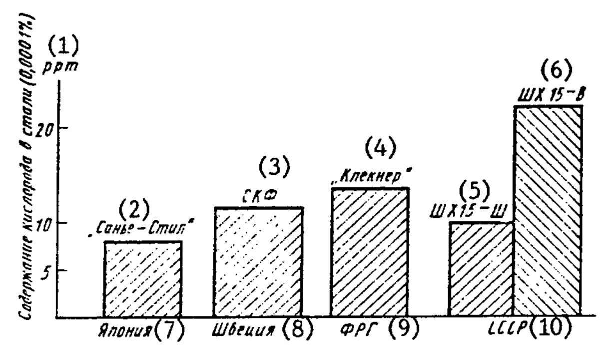

Figure 1. Oxygen Content in Bearing Steels

Key: 1. Oxygen content in steel (0.001%); 2. Sanyo Steel; 3. SKF; 4. Klekner; 5. ShKh15; 6. ShKh15-V; 7. Japan; 8. Sweden; 9. FRG; 10. USSR

the quality level of steel produced by electroslag remelting. The SKF-MR process has been developed in Sweden to produce bearing steels; the Japanese firms Aichi Steel and Sanyo Steel and the West German firm Klekner are involved in degassing steel and refining it in a ladle (Figure 2). Klekner and the Japanese firm Kobe Steel are also conducting melting in converters while conducting refining and degassing in ladles. According to data from Kobe Steel, these measures combined with continuous pouring have made it possible to reduce the oxygen content in bearing steels to 7 ppm and to thus significantly increase the bearings' life.

Of all the varieties of vacuum degassing used in producing bearing steel, batch-type degassing is acknowledged to be the most efficient. Work in this direction is being conducted in our country. One result of this work has been the introduction of ShKh15-V steel, which has made it possible to significantly increase the life of bearings used in automotive and agricultural technology.

The Donetsk Metallurgy Plant and Oskolsk Electrometallurgy Combine are conducting extrafurnace degasification of bearing steel on a batch-type unit. The Oskolsk Electrometallurgy Combine has begun researching a process for producing bearing steel based on continuous pouring. In addition, in 1986 the Oskolsk Electrometallurgy Combine started up a system to produce bearing steel on a fundamentally new technological basis, i.e., by using metallized pellets in the charge and pouring the steel on continuous blank-casting machines. (It is true that a number of specific defects have been discovered in the steel produced at the Oskolsk Electrometallurgy Combine, including systematic inclusions, developed axial inhomogeneity, and subshrinkage liquation connected with the fact that the continuous casting process has yet to be fully worked out.)

All rolling bearings for such critical applications areas as aviation are manufactured from metal whose purity is ensured by using special metallurgy methods such as, for example, electroslag remelting, vacuum arc remelting, a

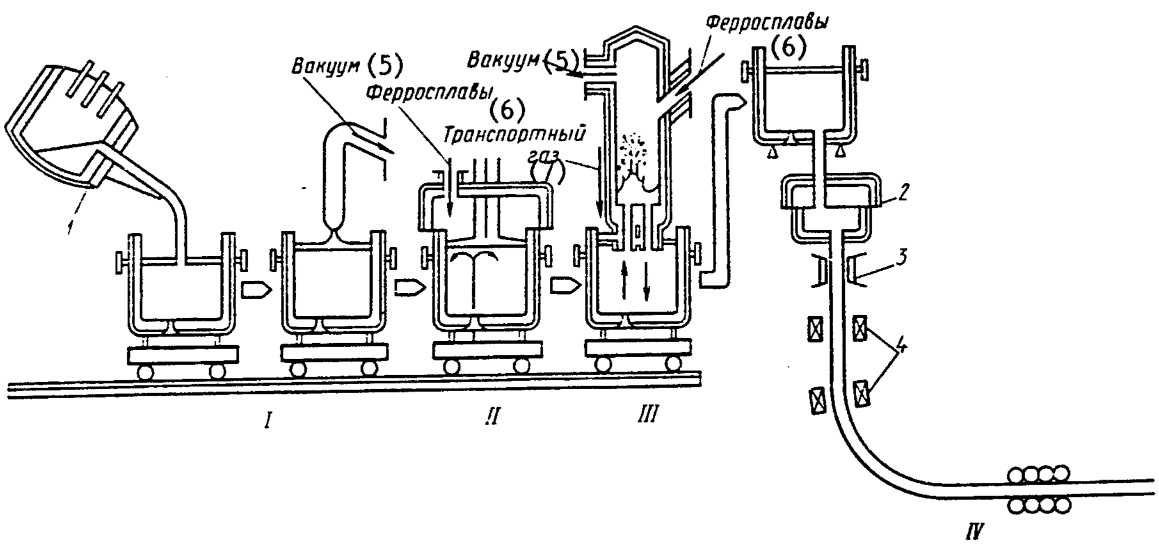

Figure 2. Diagram of the New Production Line Produced by the Firm Aichi steel
Key: I. degassing plus suctioning off of the slime; II. refining in a ladle; III. circulation degassing; IV. continuous pouring; 1. electric furnace; 2. intermediate ladle; 3. continuous casting mold; 4. electromagnetic stirrer; 5. vacuum; 6. ferroalloy; 7. conveyer

combination of electroslag remelting and vacuum arc remelting, and binary electroslag remelting and vacuum arc remelting. Of course, these methods cannot be extended to steel for all rolling bearings owing to economic considerations. This is because, for example, the costs of producing steel by the electroslag remelting method are more than twice those to produce steel manufactured by conventional methods.

An assessment of nonmetal inclusions conducting at bearing plants showed that bars and pipes of individual melts contain not only oxide but also sulfide and globular inclusions measuring up to 4 points on the scale specified in All-Union State Standard [GOST] 801-78. Their number and size fluctuate from plant to plant. The globular inclusions in the continuously cast bearing steel produced at the Oskolsk Electrometallurgy Combine are smaller, for example. And their sizes are much smaller than in analogous steels produced by other metallurgy plants. We will note, however, that this steel is not without its flaws. At the temperatures of hot plastic deformation, for example, it contains plastic inclusions with a silicate matrix and mottlings of brittle products belonging to the system Al_2O_3-CaO(MgO). One of their characteristic features is the presence of sodium in the silicate matrix, which indicates that the mixtures used in the continuous casting mold to protect the metal against oxidation may be a source of contamination. A second type of inclusion, i.e., semibrittle line inclusions, is also encountered. They are represented by coarse lines of corundum that sometimes have a manganese oxide impurity and by individual mottlings of zirconium oxide. A possible source of these are deviations in the pouring vessels that, according to analysis, consist mainly of corundum (up to 80%) with a manganese oxide impurity (up to 8%), small amounts of calcium, and oxides of other elements (silicon, chromium, iron, and sodium).

In addition, the steel produced by the Oskolsk Electrometallurgy Combine undoubtedly possesses a number of advantages: In the absence of central porosity, it has a low point inhomogeneity, i.e., a high density and low content of globular and sulfide inclusions. There is a foundation for assuming that eliminating the coarse types of macrostructural defects and slag inclusions will make it possible to transform it into steel with a rather high quality.

In the past few years, the world practice of producing quality steels has witnesses a trend toward a significant increase in the amounts of steel melted in converters. (The main advantages of converters are, first, a severalfold higher capacity than that of electric arc and open hearth furnaces and, second, a lower content of toxic impurities such as phosphorus, sulfur, and titanium.) In the United States, for example, converter melting reached 60% in 1986, whereas melting in electric furnaces accounted for 36% and melting in open hearth furnaces accounted for only 4%. At one symposium, a representative of the West German firm Klekner reported that in the FRG production of converter steel accounts for 80% of all steel melted. (The research done by this firm shows specifically that type ShKh15 bearing steel melted in converters is in no way inferior to steel produced in electric arc and open hearth furnaces.)

Japan is currently starting to use a technology of producing type ShKh15 bearing steel that includes melting steel from cast iron in a converter, extrafurnace refining, and continuous pouring with magnetic stirring in a continuous casting mold and in a section of ingot with the liquid phase to the end of crystallization. This technology reduces the steel's content of phosphorus, sulfur, titanium, and oxygen significantly (to 5-10 ppm).

One of the directions of works to increase metal quality is that of improving methods of researching bearing steels. The use of modern quantitative microscopes is making it possible to create new evaluation methods and provide the metallurgy industry with scientifically well founded requirements regarding the purity of steels and to find more feasible ways of solving the problem of increasing their quality. Research has, for example, proved that bringing domestic bearing steels up to the world level from the standpoint of quality indicators will require the following: they must be 100% degassed; the oxygen content in the steels ShKh15-V and ShKh15SG-V must be reduced to 10-15 ppm (0.0010-0.0015%); their content of oxide and globular nonmetal inclusions must be reduced; there must be a switch to the converter method of production in combination with extrafurnace treatment and degassing; and measures must be developed and introduced to eliminate slag inclusions, reduce microporosity, and restrict the oxygen content of the continuously cast bearing steels produced by the Oskolsk Electrometallurgy Combine to 10-15 ppm.

Progressive Technologies To Manufacture Automotive Conical Bearings

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[Article by V.I. Grishehenko, candidate of technical sciences, under the "Technology, Equipment, Materials" rubric: "Progressive Technologies To Manufacture Automotive Conical Bearings"]

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[Text] The No. 15 State Bearing Plant [GPZ-15] is the main producer of conical roller bearings for automobiles.

As is known, especially high requirements regarding vibration level, noise, and antitorque moment have been imposed on these bearings. The requirements have remained constant as the technical level of automotive technology has become more stringent. The many years of experience accumulated by plant specialists has shown that the aforementioned indicators largely (and, in some cases, mainly) depend on the precision and quality with which a bearing's components have been manufactured and with which it has been assembled. That is, they depend on the design of the manufacturing process. This is especially true in the case of the operations of grinding and finishing all of the components' surfaces. For this reason, the plant's work to perfect the manufacturing process has been virtually constant. It has been directed not only toward strict adherence to the specified precision and machining quality but also toward reducing the effect of different random and systematic factors on the process indicators, such as low-quality abrasive tools and cutting fluids and an unstable change in dimensions during heat treatment (and hence increased fluctuations in allowances) that are characteristic of the currently existing manufacturing process, etc.

Of course, in a number of cases improving the manufacturing process resulted in an increase in capital outlay and the labor input of the machining; these were all recouped, however, thanks to a reduction in defective products, a reduction in penalty sanctions, and an increase in the operating stability of the automatic grinding lines and sections.

We will examine the main design principles of the manufacturing processes currently existing at the GPZ-15 for grinding and finishing the components of conical bearings.

At the plant the faces of the rings of conical bearings are ground simultaneously, i.e., in one operation. This is done on models 3343, 3344, Dzhustina, and other bilateral face-grinding machines. In view of the fact that the asymmetry of the rings' faces makes it difficult to evenly trim the allowance from each face, the narrow face is machined at a reduced wheel rotation frequency (reduced grinding speed), or else the narrow and wide faces are machined by wheels with nonidentical characteristics: a wheel with a greater cutability (softer and finer-grained) is used for the wide face, and one with a lesser cutability (hard and with an increased grain size) is used for the narrow face. To ensure that the process will be highly stable and of high quality, the wheels must have a uniform structure and must wear evenly throughout the entire grinding zone. Unfortunately, this is far from always the case: the quality of the wheels produced by the domestic industry leaves much to be desired.

The quality of grinding the ring faces (an allowable variability of the ring's widths of 10 μm and a nonplaneness of the faces of 8 μm given a surface roughness of Ra = 0.63 to 0.32 μm) is, as is known, important not just in and of itself but also because the precision with respect to the axial wobble of the raceways and mounting surfaces depends on it in the subsequent operations of grinding the outer and inner rings with an eccentric basing method. The faces are therefore still ground simultaneously but in two passes. The wheels used in the second pass are straightened after about every 5,000 rings.

For bearings for which the wobble of the ring raceways to the base face must not exceed 5-6 μm, the allowable nonplaneness of the ends is reduced to 5 μm. A second

operation has been stipulated to machine rings—finishing on face-finishing machines with cast iron disks and using a kerosene and oil mixture as the cutting fluid. It takes 2 to 3 minutes to finish a set of rings.

The outer cylindrical surface of the bearings' outer rings is ground mainly on type SASL 200 x 500 eccentric grinders by wide wheels in two or three passes. Because the raceway of a given ring will "copy" the out-of-roundness of its outer cylindrical surface when the eccentric method of basing is used, the monitoring of the out-of-roundness of the outer ring during the grinding process is especially strict. The PIAK-50 instrument, which was created at the All-Union Scientific Research, Planning and Design Institute of the Bearing Industry [VNIPP], is used for this purpose. It is used to make measurements directly at the machine tool. The instrument helped, however, to establish that the raceway "copies" the out-of-roundness of the ring's outer surface with a coefficient ranging from 0.8 to 1.3, i.e., close to 1. This provided a foundation for establishing the following technological requirement for grinding an outer surface: it should be as close as possible to that established for the raceway of the same ring.

To grind the raceways of outer rings the plant uses many models of automatic internal grinding machines. All of them, however, meet one and the same conditions: use of the eccentric basing method is mandatory, the cutting speed must be between 50 and 60 m/s; and only two operations (preliminary and finishing grinding) may be performed.

The latter condition is especially important: Meeting it results in a significant increase in the stability of the machining of the raceways given the existing manufacturing capabilities and a significant increase in its precision (2 with respect to the cone angle; 2 to 3 with respect to roundness, a roughness of Ra = 0.32 to 0.4, and a buckling of 1 μm).

A rather progressive process is also used in grinding the raceways and face of the supporting skirting of the inner rings: Both surfaces are machined simultaneously, and the basing method used is the eccentric along the raceway being machined. This gives the angle between the raceway and side an instability not exceeding 15', a buckling of the side surface of no more than 1.2 μm, and a facetedness of no more than 1.5 μm. (We will note that designers do not generally count on the latter of the three aforementioned advantages and do not regulate it in their drawing; the plant has nevertheless introduced it as a technological requirement in the interests of the common cause.)

The simultaneous grinding of the raceways and face of the skirting is implemented in two operations (preliminary and finishing), which makes it possible to achieve a face roughness of up to Ra = 0.32 μm.

Thus, from the standpoint of bearing quality, the process of simultaneous grinding is without a doubt the most up to date. From a capacity standpoint, however, it is inferior to the process of separate grinding because the diameter of the abrasive wheel is significantly smaller in the first case than in the second.

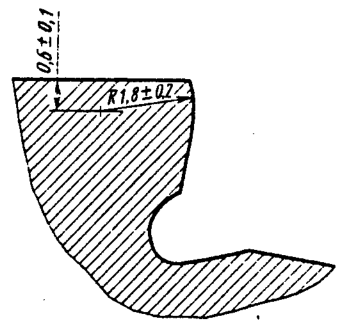


Figure 1

The process has several other distinctive features as well: the need to have grinding wheels impregnated with sulfur or manufactured on the basis of a special binder (to reduce burnt spots), the requirement that a specified ratio of the allowances with respect to the raceway and skirting face be maintained, and the requirement that rather strict checks of the buckling and facetedness of the raceway and skirting (by using a Talirond instrument) and their straightness (by using a Taliserf instrument) be performed if only selectively (twice a shift).

The grinding of the face of the support skirting in the second operation is the final grinding for this surface. To eliminate the likelihood of galling of the spherical end of the roller by the sharp edge where the working surface of the support skirting becomes the face, this transition is rounded (Figure 1) on a machine tool equipped with a built-up regulatable template (Figure 2) developed by plant specialists. It consists of a case (1), regulatable strip (3), and screws (2). The amount of curvature is specified by the position of the strip, and the quality of the transition from the working surface of the skirting to the face is controlled by the amount of force with which the tracer is pressed to the template.

The most important task when grinding conical rollers is to ensure that the faces have the required sphericity. The point is that it largely determines the precision with

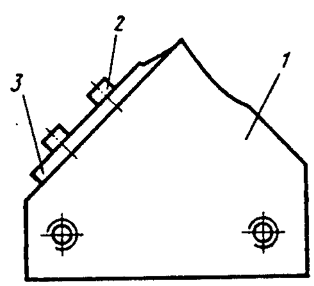


Figure 2

which the rollers roll along the raceways of the rings and, consequently, the longevity and load-carrying capacity of conical roller bearings. For this reason, only rollers with a size difference not exceeding 10 μm are sent through the operation of grinding of the spherical face. The grinding itself is done by the continuous method on VSh-680 and SKhK-54 grinders providing a sphere with a roughness of up to 0.32 and a wobble of up to 7 μm. Stabilizing the process requires mandatory adherence to two conditions: the machine's precision parameters and the quality with which it is aligned. We will examine how this is accomplished.

After having been assembled on a faceplate, the wheels are sharpened along their radius. Its size is determined by the radius of the sphere. Next, they are subjected to static balancing. The spheres are straightened to the specified radius by the overhang of the straightening mechanism's rod conforming to the specified radius and by using a tracing rule specifying the sequence of removing the allowance and reducing the amount of removed material where the roller exits the grinding wheel.

The driving disks are assembled. Next, their working surfaces are ground until the radial disk's wobble becomes equal to or less than 5 μm and that of the axial disk becomes equal to or less than 3 μm. The angle of the disks is checked by a standard roller by color. The roller should protrude out from the disks by 2 to 2.5 mm. Having the rollers at least that close to the surface will ensure that the spread of the radius of the roller's spheres is within the limits of the tolerance field.

The radius of the sphere of a ground roller is measured on an SI-260 (measurement precision, up to 2 mm) that was specially developed for this purpose. Before the measurement, the instrument is adjusted with respect to a standard roller (the roller is selected by using a Taliserf instrument). The sphere's radius is estimated indirectly by the height of the spherical belt of the roller's face.

The first bearing components to undergo the operation of grinding are the first to undergo final machining. This may be either fine polishing by vulcanite or fine-grained ceramic wheels, polishing by an abrasive belt, or superfinishing by abrasive or diamond wheels.

Each of the methods obviously provides its own working surface quality (to the ring raceways and generatrix and spherical face of the rollers) that determines such important performance characteristics of conical roller bearings as frictional losses, reliability of the lubricant used on the working surfaces, etc. In this sense superfinishing is unrivaled: it provides a significantly larger area of actual contact while the bearing is operating than does the surface produced by other methods. According to the literature, for example, the bearing portion of the surface after fine polishing amounts to about 30% whereas after superfinishing it amounts to 95%. This reduces the initial breaking-in period, which is especially important for automotive bearings because it provides the greatest likelihood of maintaining the initially specified mounting sites, pretension, precision, and operating reliability of the assembly.

It has also been proved that superfinishing has a positive effect on the condition of the surface layer of the metal, increasing (from 250 to 500 MPa) the compressional stresses in it and the depth to which they are propagated (to 7-10 μm), which is 10 to 15% greater than the microhardness of the working surfaces of bearing components.

Superfinishing of the rings of conical bearings is a comparatively new process for the GPZ-15. It is performed on special machine tools developed by the Leningrad Special Design Office of Precision Machine Tool Building and manufactured by the Vilnius Grinding Machine Plant. The technology of using them has been purely the work of the subsector. This work has led to the conclusion that ultrasonic superfinishing is the most suitable technique for mass production conditions. The process is stable, it provides a high capacity and the required (class 6) precision (see Table 1) of machining roller bearings' raceways, it reduces the level of residual compressional stresses in the surface layer from 700-850 to 400-600 MPa, and it increases the depth at which they lie from 15-17 to 40-45 mm. All of this has a positive effect on the life of the bearings.

Table 1.

Parameter	No. Outer Rings		No. Inner Rings	
	Before Machining	After Machining	Before Machining	After Machining
Roughness Ra, μm:				
0.64	4	-	20	-
0.32	96	-	80	-
0.16	-	51	-	12
0.08	-	49	-	88
Buckling, μm:				
Up to 0.1	-	68	-	78
Up to 0.2	-	32	-	22
Up to 0.3	-	-	-	-
Up to 0.4	8	-	-	-
0.5-0.8	75	-	80	-
0.8-1.5	17	-	16	-
1.5-2.5	-	-	4	-
Faceted-ness, μm:				
Up to 0.5	25	45	30	90
0.6-1	37	37	43	10
1-2	28	13	25	-
2-5	10	5	2	-

At the same time, consideration must be given to the fact that the other parameters of bearing rings (inconstancy of their diameter, nonperpendicularity of the raceway to the base face, convexity) generally remain unchanged after ultrasonic superfinishing, and the spread of the angle of the raceways even increases by a third (from +/-2 to +/-3 μm).

STsASL 50 x 500 (GDR) and 3D880 (Vitebsk Machinery Plant imeni Kirov) are used to superfinish the working surfaces of rollers. It is done start-to-finish by using a double-roller feed device. The honing sticks are pressed by a hydraulic (on the STsASL 50 x 500) or pneumatic (on the 3D880) device. The pressing force is controlled by a pressure gauge mounted on the post. During machining the roller sequentially passes under oscillating abrasive honing sticks. The first has a large grain size, while that of the final stone is very fine. The pressing force (pressure) of the honing sticks also changes from 0.2 MPa in the first position to 0.1 in the final position. In view of this, the first honing sticks are responsible for most of the metal removal and correcting the facetedness and buckling while the last are responsible for providing the required surface roughness.

Table 2 presents the change in the parameters of the rollers' surface after superfinishing. As is evident, all of the parameters change very significantly—and for the better.

Table 2.

Parameter	Before Machining, μm	After Machining, μm	Change in Parameter, %
Out-of-roundness	0.5-1.5	0.5-1	0-50
Facetedness	0.65-1.9	0.38-0.45	42-77
Buckling	0.77-2	0.18-0.52	77-74
Roughness	0.32-0.48	0.08-0.12	75
Convexity of generatrix	-	1-4	-
Amount of removal	-	2-4	-

The MK-175 machine tool, which was designed at Tolyatti Polytechnic Institute and manufactured at the GPZ-15, is used for superfinishing spherical roller faces. The main working motions of the machining operation are the oscillatory motion of the honing stick and the rotation and circular feed of the roller. The main condition responsible for high-quality implementation of the machining is that the differences between the rollers' diameters not exceed 3.5 μm. The surface quality of the rollers' spherical surfaces after this operation is generally increased: the radius of the sphere is decreased, the number of drops with respect to this parameter decreases from 11.6 to 2.5%, the facetedness of the sphere decreases from 5-6 to 2-3 μm, and its buckling decreases from 2.5-3 to 0.7-0.9 μm. The roughness of the spherical face generally ranges from 0.2 to 0.3 μm.

Pressing of the separators. Most conical roller bearings have retainers that have been stamped from strip or sheet stock. They are convenient to mass produce and, under normal operating conditions, are in no way inferior to brass retainers. Because they have a lesser mass, the lubricant generally has better access to the working surfaces. The retainers are not involved in absorbing the load and are centered on the rollers. Special attention must therefore be paid to pressing retainers. On the one hand, they must not be too "tight," i.e., they must not pinch the rollers and thereby increase the frictional losses between the retainer's bridging pieces and the rollers. On the other hand, they must not be too "free" because increased gaps between the retainer's bridging pieces and the rollers facilitates the occurrence of noise during operation (particularly at high rotation speeds). Good pressing is achieved by careful control of the press in the operation of stretching the retainer's bridging pieces and performing this operation in accordance with the established standard for stretching the bridging pieces as well as by adhering to principle of using retainers manufactured in the same batch from a single alignment of the press when feeding them to be pressed.

Quality control during the production process. Quality control is a central problem in the manufacture of conical roller bearings. The diversity of the types of equipment use, the technological problems entailed in expending the least amount of working time to produce quality products that are precise and whose errors amount to fractions of a micrometer, the making of measurements, and the massiveness of batches during the manufacturing process all make the problem of quality control a great deal more complicated. Judging by the experience of the GPZ-15, however, quality control is not being conducted unsuccessfully. The multidirectedness of the quality control is responsible for this. First, the suitability of the machine tools and accessories is checked along with the quality with which the equipment has been aligned. This is done by daily measurements of the first components by using the following instruments: the Talirond (buckling and facetedness of the working surfaces), the Taliserf (profile of the working surfaces), and the Surtronik (roughness of the working surfaces). Second, all deviations in the manufacturing process are discovered in a timely manner by using instruments designed for active monitoring and for sampled inspection of components (by a worker-machine tool operator). Third, there is systematic intake inspection of components at the bearing assembly sections and 100% inspection of vibration level, air noise, and sampled inspection of frictional losses in assembled bearings.

For example, the tracers of the machine tools that grind the rings are checked once a month, the wheels on the sphere-grinding machines are checked no less than twice a month, and all this is recorded in separate journals monitored by the division of technical control [OTK].

Thanks to these technological and organizational measures, the technology in question has begun to be developed and introduced at the GPZ-15. Also thanks to them, for example, the average vibration level of a 6-7807U91 bearing manufactured for VAZ vehicles in accordance with the new technology amounts to 5 dB, whereas that for a 6-7407A97 bearing manufactured in accordance with the conventional technology amounts to 6 dB.

Bearing Components Made of Composites

917F0141D Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 p 13

[Article by D.A. Shevchak and N.I. Simkhovich]

UDC 621.822.036.5-419.8

[Text] An important line of polymers with fillers (composites) possessing a broad range of performance characteristics has recently been created. The first of these appeared a long time, i.e., more than 30 years ago, and specialists from the No. 11 State Bearing Plant [GPZ-11] immediately became interested in them from the standpoint of materials worth trying as materials from which rolling bearing components could be manufactured. After studying different grades of polymers and after examining the experience accrued by the leading foreign firms manufacturing bearings, they concluded that the most promising structural component whose material could be replaced by a composite was the retainer of a low-rotation radial-thrust bearing (Figure 1) mounted in the steering column of MAZ [Minsk Automotive Plant] motor vehicles. And they decided on it.

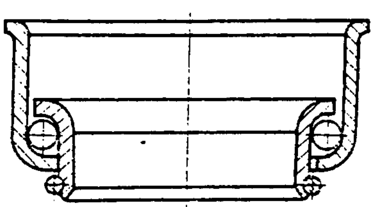
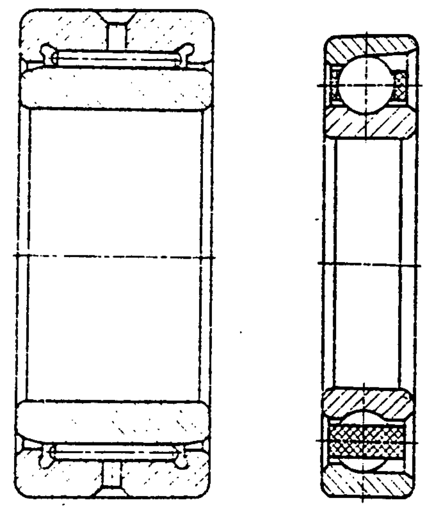


Figure 1

Together with the plant technologist, the designers corrected the retainer's design to allow for the distinctive features of the process of producing it from PA6-210 polyamide by injection molding on model DB-3328 automatic thermoplast machines in one cycle, i.e., without further processing.

The calculations were validated. After bench tests that were conducted jointly with the Minsk Automotive Plant and then after road trials, the 263706Ye bearing was launched into production.



Figures 2 and 3

Replacing the metal with polyamide and thus reducing the labor required to manufacture the retainer resulted in a significant savings for the GPZ-11 and MAZ; the performance reliability of the bearing assembly was also increased. The experience that was later accrued using polymers as replacements for metal when manufacturing bearing retainers was then extended to high-rotation and heavily loaded bearings of the series 464000, 66400, and 53000. This was especially important since once the domestic industry set up the production of composite polyamides with a glass fiber filler, it would be capable of making components whose performance qualities are no worse than those of steel components. The point is that adding glass fiber to polyamide in the amount of 27 +/- 3% increased the latter's mechanical strength with respect to the effect of short-term tensile and compressive loads, its fatigue resistance during cyclic loading, and its resistance to the introduction of solid particles in corrosive media. It also rendered the material creepless during protracted static loading, particularly at elevated temperatures (its heat resistance increased by a factor of 2.5).

The enumerated properties of glass-filled polyamides made it possible for the GPZ-11 to produce needle bearings (Figure 2) with a diameter of 1 to 100 mm and to switch over to the production of ball radial-thrust bearings (Figure 3) and, finally, series 53000 double-row spherical roller bearings (Figure 4) with a diameter up to 180 mm and with retainers made of composites.

The GPZ-11 is currently producing 4.5 million bearings and processing about 100 metric tons of plastics in its production section. The savings derived in 1987-1988 amounted to more than 500,000 rubles, and 0.4 metric tons of metal was saved. The plant's scientific-technical plan for the future calls for expanding the output of bearings with polymer retainers and for introducing new polymer composites, including some with a heat resistance up to 520 K (250°C). This will, however, require

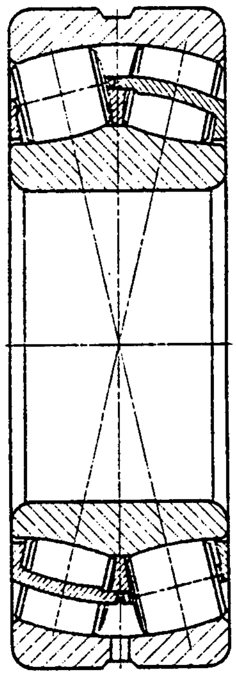


Figure 4

more of the respective composites and equipment; specifically, it will require more casting machines. There are other problems as well that must still be solved, and that will require time.

Cardan Bearings Are Improved

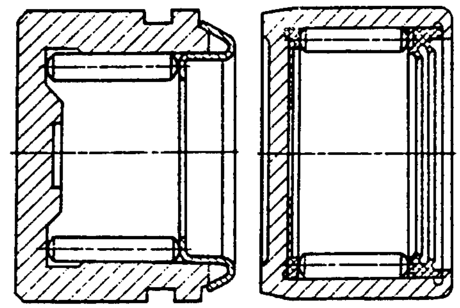
917F0141E Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 13-15

[Article by B.A. Yakhin and A.A. Anatolyev]

UDC 629.114.6-233.2.001.6

[Text] Cardan bearings are one of the most massive products produced by the bearing industry. Their output surpasses 150 million units per year. At the same time, they are very diverse from a design standpoint. This is because of the diversity of the products of the automotive and agricultural industries.

Suffice it to say that despite the relatively narrow range (16 to 62 mm) of external diameters in which the most popular cardan bearings are produced and despite the comparatively small (eight or nine) number of basic type sizes, the total number of versions of cardan bearings amounts to 50 (between four and 10 type sizes have been created on the basis of the individual type sizes).



Figures 1 and 2

This situation is understandably creating definite problems for both the bearing industry and its customers. The subsector's specialists are therefore calling, with increasing frequency and persistence, upon vehicle designers to create an array of standardized bearing assemblies based on a standardized series of progressive cardan bearings possessing an increased life.

Unfortunately, these proposals have not yet found a universal response. There has been some movement, however. Cardan bearings with a design that is rather close to or that conforms to that shown in Figure 1 are currently being produced. These are bearings with massive rings made of blanks produced by pressing and turning on a lathe. After heat treatment, the rings undergo a cycle of grinding operations and are then furnished with rollers and different types of protective and sealing devices.

This method of manufacturing bearings has one very important flaw, however: its laboriousness. More than 80 units of equipment and 200 primary and auxiliary workers are involved in the manufacture of series 704702 bearings (at the No. 1 State Bearing Plant [GPZ-1]) (in a program producing 14 million bearings a year). Moreover, a significant amount of metal goes to chips when the method in question is used.

All of this concerns the technology side of the matter. The bearing presented in Figure 1 also has design flaws. It is too heavy, and its thick-walled ring restricts the possibility of making rational use of the "live" cross section of the ring to increase the bearing's load-carrying capacity (the real need for which is dictated by increasing requirements regarding increasing the life of cardan assemblies, above all, in automotive and agricultural technology).

As research has shown, the load-carrying capacity problem may be solved. This requires creating an array of new bearings with stamped thin-walled rings that do not need additional machining. After having been hardened and heat-treated to the required hardness, their working surfaces acquire a longer life than in the case of machining.

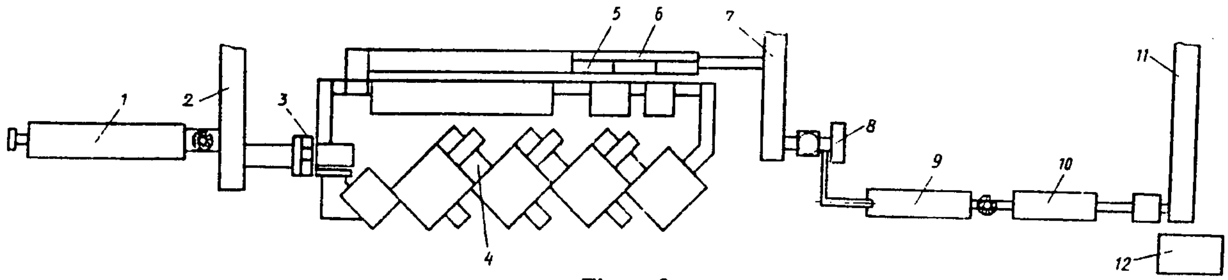


Figure 3

Figure 2 is a schematic of the design of a thin-walled stamped cardan bearing. Making it in metal showed the following: Stamped cardan bearings having the same outer diameter as a bearing with rings produced by turning on a lathe actually have a higher load-carrying capacity. They are, moreover, 25 to 35% more reliable. This is accomplished precisely by making the walls of the outer rings thinner, which makes it possible to increase the number of rollers and arrange them on large-diameter races. The inner diameter of the bearing along the rollers increases (and, consequently, the journals of its crosspieces), thus increasing its strength. Its mass, on the other hand, is decreased (on average by 25 to 30%).

The high technical and technological advantages of stamped cardan bearings over solid ones is a basis for raising the issue of not only introducing them on a really wide scale in place of the range of solid bearings currently being manufactured but also for raising the issue of developing and starting up the production of a standardized series of cardan bearings with an increased load-carrying capacity on their basis. And such work is already underway at, for example, the GPZ-10. But the collective at the GPZ-3 has moved the farthest in this direction: The plant is now producing two types of thin-walled bearings. Blanks for their rings are produced from steel strip 2.25 mm thick on multiposition low-speed presses. They are then subjected to chemical and heat treatment to cement the surface layer of the ring to a depth of 0.25 to 0.4 mm.

The annual bearing production program amounts to 4 million units. Of course, this is small. Bearing production should be switched over to rotary and rotary-conveyer lines, which have indisputable advantages over conventional methods of manufacturing products: the capability of achieving a nearly unlimited increase in capacity and the ability to use "soft" production processes thanks to a hydraulic drive to activate the actuators and a set of tools. The main point is that such lines already exist for performing the most diverse operations (plastic metal working, preforming, heat treatment, assembly, etc.). They have been created at the Automatic Lines Design Office (KBAL). The All-Union Scientific Research, Planning and Design Institute of the Bearing Industry [VNIPP] Scientific Production Association is working jointly with the KBAL and GPZ-3 to use these lines as the basis for developing the idea of organizing integrated automated sections to produce bearings.

Figure 3 is an example of the planning of such a section. The figure designations are as follows: 1, automatic rotary line for stamping rings; 2, conveyer-distributor; 3, loading pallet; 4, unit for treatment by thermal cycles; 5, pallet; 6, unloading pallet; 7, conveyer-distributor; 8, automatic high-frequency annealing machine; 9 and 10, automatic rotary line to assemble, rustproof, and pack bearings; 11, conveyer; and 12 container for finished products.

The bearing ring blanks (Figure 4a) that have been produced from a strip undergo a phosphate-coating process. They then enter a stamping line (see Figure 4), where seven operations are performed on them: first and second draw-forming (positions b and c), preliminary calibration of the bottom (position d), final draw-forming (position e) and calibration of the bottom (position f), cutting off (position g), and calibration (position h) of the raceway. The line is equipped with a hydraulic actuator drive with a force up to 300 kN that automatically controls the machining quality device (in the case where defective products appear, only the position with the defective products is disconnected; the remainder of the line continues to operate).

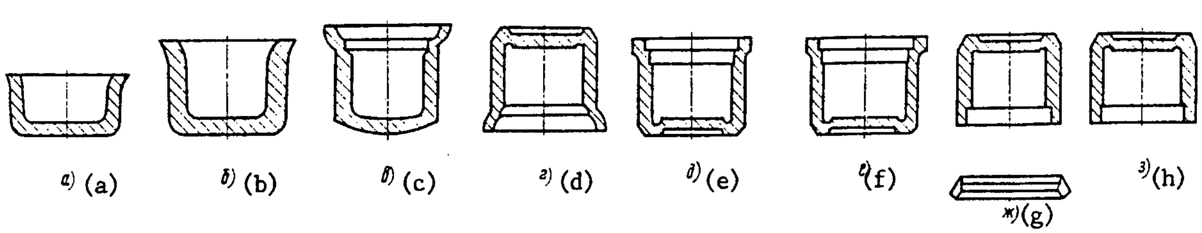


Figure 4

The thermochemical unit performs the operations of saturating, hardening, washing, and tempering the rings. Its capacity ranges from 350 to 400 kg/h, and its cassette-issuing cycle ranges from 10 to 15 minutes (depending on its capacity, it can service four to five sections simultaneously).

The automatic rotary high-frequency tempering machine anneals the upper part of the ring so that it can be subsequently bended during the operation of assembling the bearing.

On the automatic rotary assembly line, a thrust washer is mounted in the bearing, lubricant is added, the rollers are inserted, a quality check on their configuration is performed, and the upper part of the ring is bent.

The finished bearings are packed into paraffin-coated paper.

The rotary packaging lines have a capacity between 120 and 160 units per minute.

All of the section's equipment is combined into a manufacturing system by means of interline conveyer systems that transfer and distribute components between the pieces of equipment in the system's longitudinal and transverse (with respect to the "blank entry-finished bearing exit" axis) directions as well as to other systems. The lines and conveyer systems are slated for outfitting with information sensors, controllers, and program devices that will, together with the control computer system, automatically control the course of the bearing manufacturing process.

An automated shop controlled by an automatic system can obviously be created on the basis of five or six sections. But even in the case of a single section, the possibilities are not just limited to those mentioned above. By grouping components that are close in size and manufacturing technology on one automatic rotary line it is possible to machine several size groups of bearings. To do this, the rotor's positions must be equipped with different tool blocks.

The experience that has already been accumulated in operating lines based on rotary technology has shown that creating integrated automated systems to manufacture cardan and other types of needle bearings on their basis will permit a 10- to 20-fold increase in capacity and labor productivity as compared with the existing manufacturing process. Thus, while manufacturing 14 million series 704702 bearings by using the conventional technology requires more than 200 primary and auxiliary workers, a team of seven persons will be sufficient for the new manufacturing process. And thanks to the high productivity of the new process (20 to 26 million units per year), the team will be able to service two to three such sections. Moreover, the transport movements of products will be reduced by a factor of 10 to 15, and the duration of the manufacturing cycle and the area occupied by the equipment will be reduced by factors of 20-30 and 6-7, respectively. The savings derived from introducing just one such section will amount to no fewer than 18 million rubles annually.

Conventional Designations for Bearings

917F0141H Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 19-20

[Article by B.A. Byakhin and I.S. Isudov under the "Answers to Readers' Letters" rubric: "Conventional Designations for Bearings"; first paragraph is boldface epigraph]

UDC 629.114.4-233.2

[Text] "A bearing is a component that, when it fails, causes a vehicle to be 'laid up.' But, as is known, you can't always find what you need. I would therefore like to know how bearings are coded (designated) so that I can select a replacement for a failed one (or at least one that is close to it) by number."—I.A. Aleksandrov, Kaluga

Most of the bearings used in automotive products have specific additional requirements regarding the precision of their parameters, design features, the grades of lubricant used in closed-type bearings, radial clearances, etc. These distinctive features are selected in their conventional designations, which generally contain a main group of characters based on All-Union State Standard [GOST] 3189-75 and two additional groups. The first is to the left of the main part and the second is to its right.

The main group contains up to seven characters. Four of them (the first, second, third, and seventh counting from right to left) are the code indicating the bearing's overall dimensions, one character (the fourth) specifies the bearing type, and two (the fifth and sixth) establish the design version of the specific type of bearing in the specified overall dimensions.

A group of additional characters (digits and letters) to the left of the main characters is separated from them by a dash. This group may include up to four characters. The first (also counting from right to left) designates the bearing's precision class. There are seven such classes: 0.6Kh, 6, 5, 4, 2, and T (0 being the lowest and T being the highest, with the symbol 6Kh used only for conical roller bearings and the T used for radial ball and roller bearings). The second character (the digits 0, 1, 2, etc.) designates the radial clearance series, the third (also the same digits) designates the bearing's frictional torque series, and the fourth designates the bearing's category (it is provided if the bearing belongs to a category).

As we see, the group of additional characters located to the left of the main group primarily codes the important consumer properties of rolling bearings.

The second group of additional characters to the right of the main group generally consists of letters or alphanumeric characters. They are codes for many of the characteristics of bearings and their components (and are read from left to right).

Above all, they designate the materials from which the bearing's components have been made: a Yu indicates that some or all of the components are made of stainless steel; a Kh indicates that the rollers and rings or one ring is made of carburized steel; an R indicated that the components are made of heat-resistant components; a Ya indicates that the component is made of a seldom-used material such as glass, ceramic, etc.; a G indicates that the retainer is made of ferrous metals; a B indicates that the retainer is made of tinless bronze; a D indicates that the retainer is made of aluminum alloy; an L indicates that the retainer is made of brass; and a Ye indicates a plastic retainer. After the letter there may be a one- or two-digit numeral (for example Yu1, Yu2, L1, Ye12, etc.) designating the variety (one digit) of material or else a combination (two digits) of different materials.

The second characteristic, i.e., design changes in the basic bearing design, are coded by the letter K (when necessary, in combination with a one- or two-digit number). Along with the letter K, roller bearings with a modified contact also use the letters A and M. They are generally attached to bearings with a load-carrying capacity.

Special technical requirements regarding roughness, coatings, completing sets, etc., are designated by the letter U; the temperature at which the bearings' rings was tempered (433 K or 160°C) is designated by a T; the lubricants used in a closed-type bearing are designated by an S in combination with a digit after it (each digit indicates a specific grade of lubricant); and special requirements regarding the bearing's noise level characteristics are designated by the letter Sh.

In the absence of specific requirements, the additional characters and the precision class 0 are omitted.

As an example, we will decode several conventional designations of bearings used in the automotive industry.

—The 6-170412L gear box bearing: Here the 6 indicates the precision class, the 17 indicates the specifics of the bearings design (the 1 indicating a groove under the locking ring on the outer ring and the 7 indicating channels on the sides of the rings to secure hinges); the 0 indicates a radial ball bearing; the 4 indicates the heavy series of bearing diameters; the 12 indicates the bearing's inner diameter (obtained by dividing the actual size by 5); and the L indicates that the retainer is made of brass.

—The 986714KS17 clutch bearing: Here the 9 indicates a special design of the outer and inner rings; the 8 indicates a closed-type bearing with protective devices on two sides; the 6 is the precision class; the 7 is the diameter series; the 14 is the code for the bearing's inner diameter (obtained by dividing the actual size by 5); the K indicates an opening in the inner ring to replenish the working lubricant; and the S17 indicates that the working lubricant Litol-24 was placed in the bearing when it was manufactured.

Progressive Rolling Bearing Designs for Modern Motor Trucks

917F0141C Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 p 12

[Article by B.A. Boryakhin and I.S. Sudakov]

UDC 629.114.4-233.2

[Text] The creation of new families of motor trucks with an increased payload capacity and useful life has made it necessary for the bearing industry to develop new designs and update its series-produced bearings. And the work was done: more than 150 type sizes of new progressive bearings were placed at the disposal of those building motor vehicles. These new bearings included conical roller bearings with a 15 to 30% increase in their dynamic and static load-carrying capacity; ball and roller radial bearings for which these same indicators were improved by 10 to 30%; bearings made to be one with vehicle components (for example, the water pump bearings of VAZ vehicles); small, ringless roller needle bearings intended for gear box pins and transfer cases; bearings belonging to elevated precision classes; and bearings with controlled requirements regarding friction moment and with surfaces having increased wear resistance. From a technical level standpoint, all of these bearings conform to the bearings produced by the leading foreign firms.

This is, so to speak, an overall picture of the state of affairs regarding bearings for modern motor trucks. A more detailed examination would look like the following.

Let us take bearings for driving axles, transfer cases, and wheel hubs, i.e., those that operate under the greatest loads and under conditions of complex radial and combined dynamic effects. The situation here, if it is considered from the standpoint of the presence of modern designs and the smoothness of series production, is rather favorable. Thus, 40 type sizes of 7000A radial-thrust conical roller bearings have been developed and are being produced for subassemblies with predominantly radial loads. These bearings have an outer ring taper angle of 12 to 15 degrees, and their roller contact has been modified.

For subassemblies with prevailing axial loads there are the 27000 (12 type sizes) radial-thrust conical roller bearings with an outer ring taper angle of 27 and 20 degrees and a modified roller contact. Those bearings

with a taper angle of 20 degrees are optimal with respect to their axial rigidity and the durability of the subassemblies in which they are used.

Other new bearings include the 97218A and 297308AKU radial-thrust double-row conical roller bearings; radial roller bearings with short cylindrical rollers (both with and without a retainer) that are intended to operate in subassemblies with high loads and insignificant rotation frequencies; needle radial ringless bearings with a plastic retainer (664913Ye, 664916Ye, 66480Ye5, and SL455538); and 2527/32Ye5 and 664806Ye special bearings that are combined with the axis of the planetary reducing gear, thus resulting in supports with a significantly reduced specific metal consumption and improved compactness.

The second group of bearings used in modern motor trucks comprise clutch bearings to disengage the clutch.

It is known that these motor truck subassemblies operate under conditions of high speeds and temperatures, vibration, noncoaxiality, and fouling and that reconditioning them is very, very laborious. Hence the attempt to increase the useful life of clutch bearings up to the useful life of the power plant. And the problem has been solved. Two types of bearings have been developed for clutches: The 986811KS9 is a closed ball, closed-type radial-thrust bearing with an opening to add lubricant during the process of its operation. The 280114S23 (520114S23) is a closed ball radial single-row bearing with one-time application of lubricant and two protective washers. Tests of these bearings on GAZ, ZIL, and KamAZ vehicles, as well as on vehicles produced by the English firm Automotive Products, have shown that they are durable, reliable, and capable (unlike series-produced bearings) of self-alignment in a subassembly.

The All-Union Scientific Research, Planning and Design Institute of the Bearing Industry Scientific Production Association is working on a fundamentally new, even more improved design for self-aligning radial-thrust bearings with stamped rings. They do not require a great deal of metal, are simple to manufacture, and have high performability.

The third group consists of bearings for gimbal drive joints. This group has also been virtually completely updated. Specifically, it is now based on needle bearings with one outer ring and with a more effective contact surface, spherical roller faces, improved lubrication (with No. 158 lubricant), and stronger seals. There are eight type sizes, including five with an increased load-carrying capacity (804704K3S10, 804805K2S10 [904805K1S10], 804707K3S10, 804807K3S10, and 804709K5S10). Seven of them (i.e., all except 804704K3) have built-in rubber reinforced (turned) single- and double-edged seals, and the bottom end of their ring makes it possible to fix the bearing in a fork by using a cap. All of the type sizes may be used both with an additional end seal or without one. In the former case, the cardan joints' longevity increases by a factor of 2 to 5, which eliminates the problem of bearings being components that limit the performability of gimbal drive subassemblies.

The fourth group of new bearings consists of the 704900U, 704902U (704902 and 704902K6U), and 704702KU2 for steering joints. They do not have built-in seals but do have a groove on the rings to permit fixing by locking rings. They are sealed by using cork and rubber rings with a round or square cross section. (This type of sealing is of course worse than in the case of rubber reinforced, i.e., radial-type, single- and double-edge seals; however, they still satisfy operating conditions).

It should be said that the joint design where the bearing is secured from the side of the bottom by locking rings is more easily manufactured than is the design calling for securing by means of a cap. It is also less laborious to manufacture and permits automated assembly of the joints and control of the axial clearance and position of the crosspiece in the joint, thereby reducing the imbalance, noise, and dynamic loads on the subassembly. This is precisely why the All-Union Scientific Research, Planning and Design Institute of the Bearing Industry is continuing to work on bearings that are secured in joints by locking rings. These bearings include the 804805US10 (804805K4S10), 804707K5S10, and 804807K4S10 with installation facets on the outer rings and a high geometric precision of arranging the installation surfaces. Also being created are bearings with thin stamped rings that have a dynamic load-carrying capacity that is 20 to 40% higher than that of bearings having massive rings and a design life that is twice as long. The amount of metal required for such bearings is reduced by 20 to 40%, and the labor required to manufacture them is reduced by 20 to 30%.

NC Machines and the Precision of Turning Rings

917F0141K Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 28-29

[Article by Yu.A. Sudin, candidate of technical sciences]

UDC 621.822.723.002.2:621.941.2-259

[Text] NC machine tools are an acknowledged means of automating bearing production. They make it possible to increase demand adaptability and flexibility, reduce the time required to realign equipment, and reduce the labor input required to manufacture bearing components. But they have other advantages as well. Specifically, they create favorable prerequisites to increase the precision of turning these components on a lathe and reducing the allowances required for subsequent operations.

When analyzing the factors affecting machining precision it is above all necessary to determine the predominant errors that exert the greatest effect on the precision of the size and geometric parameters of the resultant components.

In fact, the precision of machining on all machine tools depends on many errors connected with the machine tool, the tooling, and the workpiece. NC machine tools are no exception in this sense. Indeed programming errors still occur. Experience has shown, however, that the main subassemblies and mechanisms of the NC lathes that are produced in the GDR (models DF2, DF2/3, DF3, etc.) and used at our bearing plants have a high static and dynamic rigidity and good program control systems. In other words, they possess high precision and rigidity parameters. It may thus be concluded that under normal operating conditions, the main source of errors affecting the precision of turning workpieces with such machines will be mainly connected with the elastic deformation of the workpiece, tooling, and accessory as well as errors in configuring the blank and programming. In the final analysis, these are the rationality of designing a manufacturing process, selecting clamping accessories and cutting tools, and the optimality of the designation of the machining modes. As the practice of operating NC machines at bearing plants has demonstrated, however, the smaller the size and the lesser the uniforming of the allowance on a blank, the better.

In general, the following may be said. Well-prepared base surfaces, standardized cutting tools with changeable plates, and precise and rigid clamping accessories are "work" toward precision. This is not always the case, however. For example, the standard clamping chuck designs supplied as a set with NC machines do not fully meet the specifics of bearing production, and they do not always provide the required precision and rigidity of fastening when rings of different design modifications are secured. This is precisely why specialists from the All-Union Scientific Research, Planning and Design Institute of the Bearing Industry and No. 1 State Bearing Plant [GPZ-1] have developed a range of standardized clamping chucks (Figure 1a presents a collet chuck, and Figure 1b presents a jaw chuck) to secure bearing rings along their outer and inner surfaces. Each of these chucks makes it possible to secure and machine bearing rings with a base diameter from 60 to 100 mm without realigning the frame. (During realignment for another type of ring only the replaceable clamping components and end stops are changed.)

To reduce the errors in manufacturing the chucks themselves, their main surfaces (which determine the precision of centering) are subjected to additional turning by using powdered ceramic cutters at their own "workstation," i.e., directly after being configured on the NC machine. This makes it possible to reduce the wobble of the chucks to practically zero.

To estimate the stability of the resultant precision of the size parameters of rings it is possible to use the precision margin. This coefficient, which is frequently used in technological research, equals the ratio of the manufacturing tolerance to the actual machining precision (the precision and stability of the manufacturing process are assumed to be high if this coefficient is greater than 1; its numerical value specifies the relative precision margin). Analysis shows that when components are machined on NC machines, the precision margin for components manufactured on NC machines equals 1.7. It is characteristic that the stray field of the dimensions is significantly narrower than in the case of conventional machine tools, whereas the out-of-roundness is within the range of 0.05 and does not exceed 0.07 mm (the tolerance for this parameter is 0.12 mm).

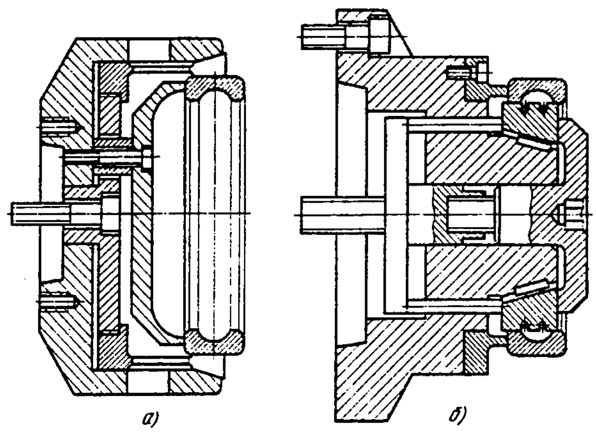


Figure 1

Thanks to the high precision of the rings' size and geometric parameters of rings, their allowances are reduced both after turning on a lathe and for subsequent grinding operations. This in turn creates real prerequisites for reducing the labor input required to manufacture and increase the quality of finished bearings.

A number of bearing plants have recently developed processes for turning hardened bearing rings on lathes. In this case the machine tools are outfitted with cutters having plates made of powdered ceramic and ultrahard materials. The results confirm that when the technology is carefully debugged, using high-precision rigid clamping accessories and selecting the optimal cutting tools and cutting modes make it possible to refrain from preliminary and, in a number of cases, finishing grinding of rings' main surfaces.

The experience accrued during the operation of NC machines thus makes it possible to conclude that given the technological preparation of production devised, using machine tools results in bearing rings with high size and geometric precision, which is very favorable from the standpoint of increasing their quality and in subsequent finishing operations as well.

In Consideration of the Functional Requirements Imposed on Bearing Assemblies

917F0141F Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 15-16

[Article by V.A. Lapenko]

UDC 621.822.6.004

[Text] The attempt on the part of many machine building enterprises to increase the quality of their product and its competitiveness on the world market and to have their new products conform to strict consumer requirements resulting in scientific-technical progress has made it necessary for specialists of the bearing industry to address the task of creating new bearing designs using original engineering solutions and modern materials and technologies. This is one side of the situation. On the other hand, the enterprises' transition to new economic forms of management, cost recovery, and economic accountability has necessitated new, more economically feasible principles of organizing bearing production.

The many years of experience that have been accrued in using bearings in assemblies and mechanisms not requiring exact revolution has thus shown the correctness of the principle according to which bearings with simplified designs need to be created for such purposes. These are ball radial-thrust bearings without rings and with stamped rings, cardan and hinge bearings, precision class 8 or 7 ball and roller bearings, and a number of other bearings. The condition of manufacturing such bearings is one and the same: meet the specific technical requirements of the specific customer. Both domestic and foreign practice have shown that even for machines and mechanisms with a very high technical level (electric motors, computer and video technology, instruments for use in precision mechanics), it is possible to use bearings that have been made to be universal, provided they have been manufactured in accordance with the parameters of the raceways and rollers of the given precision class level (with the exception of mounting fits manufactured in accordance with class 6). Nevertheless, those creating items having a high technical level are making the change with evident unwillingness. Moreover, analysis confirms that even more expensive bearings are being used in places where using bearings with their precision is not rational. This is resulting in expenditures that are in fact unjustified. A subdivision of bearings into three (A, B, and C) categories depending on their purpose and the conditions under which they are used was introduced in order to avoid these expenditures. These categories have now been decreed in All-Union State Standard [GOST] 520-89 "Rolling Bearings. General Specifications," which took effect on 1 January 1990.

Category A includes bearings belonging to precision classes 5, 4, and 2T that have been improved with respect to one indicator or another. The bearing modifications Sh3, Sh4, and Sh5, for example, are made with a lower maximum allowable vibration level. All modifications are limited with respect to allowable buckling and out-of-roundness of their rolling surface. In addition, some have a controlled contact angle, and some have a controlled contact angle and frictional torque. The axial and/or radial wobble of some of them must conform to the next (next higher) precision class. For yet others, frictional torque and/or contact angle constraints are also applied on top of the latter constraints. There are 16 different combinations in all.

Category B includes the very same bearings but with constraints that are less strict than the ones for category A and with a smaller number (nine in all) of combinations. Thus, while 15 of the 16 versions in category A have constraints with respect to the buckling and deviation of their surfaces, only one bearing in category B has such constraints. The constraints on most versions (with the exception of three: buckling and out-of-roundness, axial and radial wobble, and frictional torque and contact angle) relate to one indicator: wobble in one direction, contact angle, or frictional torque. It is true that this category includes a constraint that does not exist in category A, i.e., a constraint regarding the height, installation height, and width of the rings.

A great many types of bearings belong to category C. These include the following:

—ball and roller bearings of the precision classes 8, 7, 0, and 6 with no requirements regarding vibration level, frictional torque, or other different requirements regulated in categories A and B;

—all bearings manufactured in accordance with the constraints stipulated by GOST 4060-78 ("Roller Needle Bearings With One Outer Stamped Ring"), GOST 3635-78 ("Hinge Bearings. Specifications"), Branch Standard [OST] 37.006.002-76 ("Roller Bearings With Twisted Rollers. Types and Main Sizes"), and OST 37.006.002-76 ("Reconditioned Ball and Roller Bearings. Specifications");

—bearings meeting the requirements of one of the following 17 specifications [TU]:

** 37.006.042-81 ("Multiple-Row Ball Radial-Thrust Bearings Used in the Supports of Turbodrill Assemblies and Downhole Propeller Engines");

** 37.006.045-77 ("Ball and Radial-Thrust Bearings Without Rings");

** 37.006.052-80 ("Single-Row Ball Radial-Thrust Bearings With Stamped Rings");

** 37.006.065-74 ("Cardan Roller Needle Bearings");

** 37.006.071-75 ("Large Spherical Roller Thrust Bearings for Regenerative Rotary Air Heaters of Thermal Power Plant Units");

** 37.006.074.84 ("Roller Bearings With Twisted Rollers and a Split Outer Ring");

** 37.006.079-88 ("Hinge Bearings With a Capron Inner Ring");

** 37.006.084-77 ("Single-Row Radial Ball Bearings With an Outer Ring That Has a Spherical Surface and Seals");

** 37.006.088-78 ("Rollers-Bearings for Trolleys and Carriages of Freight and Push Conveyers");

** 37.006.109-82 ("Single-Row Radial Ball Bearings With Seals With a Spherical or Cylindrical Surface of Their Outer Ring and With a Square or Hexagonal Opening in the Inner Ring");

** 37.006.111-81 ("Ball and Roller Rollers-Bearings for the Hoisting Mechanisms of Automotive and Electric Loaders");

** 37.006.115-83 ("Ball Bearings for Linear Movement");

** 37.006.129-84 ("Roller Rolling Contact Bearings With Long Cylindrical Rollers");

** 37.006.137-85 ("Type 982 807M Radial Roller Bearings");

** 37.006.143-85 ("Single-Row Radial Ball Bearings With a Solid Lubricant Filler");

** 37.006.144-85 ("Roller Needle Bearings With One Stamped Outer Ring");

** 37.006.158-88 ("Rolling Bearings for the Roller Supports of Belt Conveyers and General-Purpose Roller Tables").

—bearings for which no standards or specifications exist but whose technical requirements are specified in designer's documents.

Specific values of additional technical requirements are established in three specifications: 37.006.152-89 ("Rolling Bearings. Category A Bearings. Specifications); 37.006.153.89 ("Rolling Bearings. Category B Bearings. Specifications); and 37.006.154-89 ("Rolling Bearings. Category C Bearings. Specifications). All took effect on 1 January 1990.

The decreeing of the bearing categories necessitated changes in their conventional designations. This was done in GOST 520-89. According to that standard, bearings belonging to category A or B would be prefaced with the respective letter (for example, A125-3 000 205 or BO-205). No letter would be used for category C (205, 6-205, or 8-306). Additional specifications regarding bearings belonging to categories A and B also have their own conventional symbols that are placed before the category symbol. For example, bearings with increased requirements regarding radial wobble are designated as follows: 2A4-201 or 2B0-7517. Bearings with a controlled vibration level or with extra regulation of their vibration level have the conventional symbol Sh with or without a digit (Sh, Sh1, Sh2, Sh3, Sh4, or Sh5) at the end (for example, B6-405Sh1, B0-42205KMSh, B5-306Sh2, A5-7606K1Sh3, or A4-2314KMSh4).

From the standpoint of its technical requirements regarding bearings, GOST 520-89 conforms fully to the international standards ISO 492-86, ISO 199-79, and ST CEMA 774-85 and simultaneously establishes inspection methods and rules for accepting, marking, packing, transporting, and storing bearings. It also contains instructions regarding their application and use as well as manufacturer's warranties.

The set of new technical documents (GOST 520-89 and bearing category specifications) introduced in 1990 will make it possible to manufacture bearings for the national economy that have six vibration level standards and that are controlled in three frequency bands. It will also be possible to manufacture bearings with different additional technical requirements (23 versions), without additional requirements, simplified designs, and designs with eased technical requirements.

So wide a variety of requirements regarding one and the same bearings will make it possible to meet virtually any need. The problem of economically feasible expenditures to manufacture them cannot, however, be solved without revising the prices for bearings. The prices are not always favorable to both customers and bearing manufacturers.

Development of a CAD System To Design Bearings

917F0141G Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 12, Dec 90 pp 16-17

[Article by L.V. Chernevskiy, doctor of technical sciences, P.A. Ilyukhin and V.F. Sviridenko, candidates of technical sciences, and A.A. Spektor, candidate of physical and mathematical sciences]

UDC 621.822.6.001.63:658.512.2.011.56

[Text] The association has developed the Podshipnik [bearing] CAD system intended for preparing design and technological documentation. It includes two groups of design subsystems—for planning and design work and for the technological preparation of production.

The first group forms three subsystems: a subsystem to calculate parameters and automate the production of design documentation for bearings (PS RAPKD), which makes it possible to perform these operations for 70% of the currently existing type sizes of bearings; a subsystem to analyze the quality and longevity of bearings (PS

AKD); and a subsystem to analyze the applicability of and select bearings (PS APVP). The second group also includes three subsystems: one to design routing and operations technology, one to design accessories and tooling, and one for automated preparation of control programs for NC machine tools.

Of course the bearing CAD system also includes service subsystems. There are three: a monitor system (that controls the computing process), one to manage and maintain the data base, and one for the computer graphics.

The bearing CAD system is implemented through a mutually connected set of support components (algorithms, software, data base organization and management, methodological support, language, hardware, and organizational support) geared toward automating the design of bearings and the technology used to manufacture them. All components ensure the integration of the CAD system during the performance of the interconnected tasks entailed in the design and technological preparation of production. The use of shared or compatible hardware, similar methods of modeling and compiling sketches and graphics, and a shared data base is a necessary condition of the system's efficiency.

The RAPKD subsystem performs four tasks: selecting and implementing of different calculation and design tasks (calculation of geometric parameters, technical requirements for bearings, and their corrections; printing out the computation results; designing geometric images and outputting them to a graph plotter or graphic display); producing finished files of computation data for the aforementioned operations with respect to the conventions used for bearings or their components; permitting interaction between the designer and computer and, when necessary, changing the sequence in which operations are performed; and producing fully formed sets of sketches of bearings and their components.

The data base organization and support is implemented by a design documentation data base management system that stores information on all of the bearing and bearing component parameters that are contained on a sketch, the main characteristics of the bearing, and data from its technical standards documentation.

The geometric parameters and technical requirements are calculated in accordance with bearing industry standards. It is possible to optimize a bearing's inner geometry for specific operating conditions so that the parameters of this geometry satisfy both the selected optimization criteria (maximum life, minimum energy losses and contact stresses, etc.) and the selected system of constraints specified by the user and reflecting the main factors determining the bearing's performability under the given conditions.

The following are taken into consideration when bearings are optimized for gas turbine engines: axial (radial) load, bearing rotation frequency, lubricant viscosity, lubricant pumping intensity, and surrounding temperature. The constraints imposed on bearings deal with the magnitudes of the axial and radial clearances, with the balls not extending to the skirting, and with two-point contact in the operating mode. A set of programs to calculate a bearing's performability characteristics is used during the optimization.

Designing bearings in the PS RAPKD assumes active interaction between the designer and computer. The calculation of a bearing's parameters is a well-structured task; most of its operations may be formalized and performed on a computer. In certain situations, however, certain bearing parameters may be changed during the process of interaction with the computer. Furthermore, an interactive mode gives the user the capability to constantly monitor the design and its correctness, correct it, and make independent decisions in accordance with the results obtained. In other words, although it reduces the degree of automation, interactive organization of the computer process increases its flexibility.

The interaction is based on a "menu" technology, i.e., a set of specific procedures or design operations having a code by which the user can call it from the computer's memory.

The result of the operation of the PS RAPKD is a set of design documentation formulated in accordance with the requirements of the All-Union State Standards [GOST].

The APVP subsystem may perform four tasks: select bearings on the basis of an analysis of the results of their tests and the experience accrued in using data regarding their price and production plan, select designs of both bearings themselves and bearing assemblies, issue data required to make decisions regarding the development of a new bearing or selecting from among existing bearings and obtain on-line information from the file on the use of bearings in specific product assemblies and about bearings' operating conditions and modes, and design bearing assemblies.

The source information for this subsystem consists of the requirements that have been imposed regarding using bearings in specified assemblies.

The AKD subsystem is intended for systematic accumulation, storage, and on-line use of information about the quality and life of bearings based on the results of plant tests. Quality is assessed on the basis of the number of bearings deviating from the standards to the total number of bearings inspected and on the basis of the ratio of their actual life to their design life. This is done by means of bench tests. (Diagrams of bearings' quality and life may be produced by plants and by bearing type, precision class, size group, material, manufacturing specifications, etc.)

The second group of subsystems perform their own specific tasks.

The subsystem for computer-aided design of routing and operations technology has three functions: formulate source information by standard manufacturing process for the main design groups and size ranges of rolling bearings (develop a formalized language with regard to the specifics of the bearing industry); determine criteria for selecting a standard machining route or designing a new route; and computer-aided design of manufacturing operations (press-forging, turning on a lathe, heat treatment, grinding, and finishing). These tasks are performed by using mathematical models in the form of block diagram relationships that are reflected by functions of the characteristics of bearing components (configuration, dimensions, machining precision, etc.) and functions of generalized technological experience and that are well recommended in the practice of making technological decisions.

Efficient operation of the entire integrated CAD system to design bearings requires organization of data based on models of design objects and implemented by the system's data base manager [DBMS]. In view of the need for decentralized data processing, it is advisable to use distributed (on-line) data bases to store intermediate information and to use the main (central) data base to store the source information as well as the end results of the design and other systemwide information.

The CAD system to design bearings has been designed for step-by-step development. When realized fully, it is transformed into an expert computer system capable of performing the operations and planning tasks entailed in the design and technological preparation of rolling bearing production.

Automated Assembly Line LA-60

917F0093E Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 10, Oct 90 pp 32-33

[Article by N.I. Khvinevich, Scientific-Industrial Association "Avtopromsborka" (Assembly Lines for Automobile Industry)]

UDC 621.757.06-52:658.527:629.113.012.1-214.6

[Abstract] An automated assembly line for axles of three MAZ (Minsk Automobile Plant) cars has been developed at the Minsk(?) Office of Automobile Industry's Institute of Transportation Economics (MKTEIavtoprom) which can produce 16 axles per hour when operating at 80% capacity. It has nine positions, two them only mechanized and one manual. The line consists of an upper roller conveyor and a lower chain conveyor, connected by two bucket carriers ascending and descending respectively. It operates with 10 planetary jigs and 4 automatic manipulators, its equipment also including one hydraulic post and two electric racks. Its operation in either automatic or setup mode is controlled with a programmable monitor, encoded information about the status of a part in process being recorded on and read off a magnetic tape. Figures 2.

Composite Polymer Material for Friction Pairs

917F0093F Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 10, Oct 90 p 33

[Article by N.D. Myasnikova and V.V. Manturov, Kamo Automobile Plant]

UDC 621.893:678.5-419.8

[Abstract] The polymer material SAM-3 developed by the Scientific Research Institute of Automotive Materials consists of a polyamide filler and an antifriction additive such as polyformaldehyde, polyethylene, graphite, or other. In the raw state this composite material forms gray lumps, which are reprocessed by pressure casting into machinable blocks. The finished material is a self-lubricating wear-resistant one suitable for sleeve bearings, designed for a rubbing velocity of 1 m/s under a pressure load of 5 MPa without lubrication or with very little of it at temperatures from -40°C to 100°C. Its density is 1113 kg/m^3. The coefficient of sliding friction against steel does not exceed 0.3 at a rubbing velocity of 0.5 m/s under a pressure of 1.25 MPa. Its tensile and compressive strength is 70-80 MPa and 80-90 MPa respectively. The material replaces fiberboard, textolite, and nylon. Sleeves made of this material have been operating for three years without replacement in conveyors at 14.5 rpm shaft speed under 2 MPa pressure. Use of such sleeves has saved 60,000 rubles annually in production costs at one of the Kamo automobile shops alone.

UDC 621.43-192:621.43(213)

Reliability of Engines Under Desert and Semidesert Conditions

917F0093B Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 10, Oct 90 pp 15-16

[Article by A.M. Efendiyev, candidate of technical sciences, Bukhara Institute of Technology]

[Abstract] An extensive reliability and life expectancy study of six automobile engines under desert and semidesert conditions was made in which ZIL-131 (Moscow Automobile Plant imeni I.L. Likhachev), ZMZ-53 (Zavolzhsk Automobile Engine Plant), "Ural-375", YaMZ-238 (Yaroslavl Automobile Engine Plant), YaMZ-238NB engines were tested at various locations. The study has yielded extensive statistical data on their failure rate prior to first scheduled major maintenance and prior to final write off (ZIL-131, YaMZ-238) but also on the performance of other essential automobile components: air injection and cleaning system, engine

cooling system, lubrication system, power transmission, running gear, steering control, brakes, electrical system, body and accessories, and chassis. The results indicate that all reliability indicators drop sharply, but in different ways, as the mileage builds up and the technical condition of the engine deteriorates. Most critically influencing the engine reliability are the air injection and cleaning system and the lubrication system. An engine should, therefore, be selectively matched for operation in a desert or semidesert and particular attention needs to be paid to those two most critical systems. Tables 1.

Special Design Features of AZLK-2141-01 and AZLK-21412-01 Cars

917F0093C Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 10, Oct 90 p 18

[Article by A.Ye. Sorokin]

UDC 629.114.6

[Abstract] The design of the AZLK-2414 (Moscow Automobile Plant imeni Lenin Komsomol) automobile with front-wheel drive has been modified so as to lengthen its life expectancy from 150,000 km to 200,000 km. The body construction has been altered and some changes have been made in the power equipment, in the front-wheel drive and clutch system, and in the chassis. Also some materials have been changed. The weight of the automobile has been reduced by installation of a lighter and maintenance-free battery, replacement of the 4.5 mm thick glass rear and side windows with 3.2 mm thick ones, installation of a single-grille radiator with plastic cups, and by installation of a plastic fuel tank with larger (5.5 liters) capacity sufficient for traveling 80 km without refill. The transmission gear ratios have been revised for better dynamic performance and better fuel economy. The vibroacoustic characteristics have been improved by lining the muffler with molded sound insulation and an additional jacket. Radio interference has been attenuated by shielding the spark plugs. Other modifications improving either comfort or appearance are: a steering column which absorbs vibrations and has teflon-coated front suspension bearings which make it easier to turn the wheel, additional hangers holding the exhaust system up, front and rear fenders with aprons for better protection of the wheels, a better designed side mirror, flexible trunk lid hinges, car seats made of a thinner but more wear-resistant and less light-sensitive washable fiber cloth, better shaped arm and head rests, a car interior lined with color plastics, means of keeping debris out from under the hood, a remote hood latch release mechanism with a shutter preventing accidental opening of the hood. All these features have been incorporated in the two AZLK-2141-01 and AZLK-21412-01 modifications of the model AZKL-2141 car. At an extra cost can furthermore be installed: fog-proof headlamps with wipers and better beam control by the driver, rear window wipers, and a tow lug in the rear, also brake and clutch linings made of an asbestos-free material.

Thermochemical Treatment of Powder-Metal Parts

917F0093D Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 10, Oct 90 pp 27-28

[Article by Ya.M. Gendlin, V.S. Ivanov, S.Yu. Lopukhin, and R.M. Sedunova, Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom)]

UDC 621.785.5:621.762.002.6

[Abstract] Thermochemical treatment of powder-iron parts is evaluated, considering the differences between iron powders produced by mechanical pulverization (PZhV 2.200.26, German-made WPL-200) and those produced by chemical reduction (NZhV 2.160.25, Swedish-made NC 100.24). Their treatment after sintering, namely oxidation followed by sulfiding or nitriding, was studied by metallographic methods: microstructural examination and x-ray structural analysis after each process. Sintered specimens made from both kinds of powder consisted of equiaxial ferrite grains, those produced mechanically being larger than those produced by reduction and showing traces of secondary recrystallization. Oxidation at 540°C under a vapor pressure of 0.4 MPa for 3 h and subsequent furnace cooling at 350-400°C produced oxides uniformly distributed over the cross-section and covering the grain boundaries, wider ones in specimens made from mechanically produced powder. Sulfiding by impregnation with molten sulfur at 120°C and subsequent annealing at 540°C for 1.5 h produced sulfides uniformly distributed over the cross-section but not uniformly along grain boundaries in specimens made from mechanically produced powder. Coarsening and growth of sulfides and oxides in specimens made from mechanically produced powder were found to degrade the mechanical properties. Nitriding in a "Rekat" furnace at 860°C in an 11 % natural gas + 86 % SF_6 + 3 % NH_4 atmosphere for 1 h followed by oil quenching and then tempering at 180°C for 2 h produced a martensitic microstructure with an austenite content of 3-5 % in specimens made from powder produced by reduction and 7-11 % in specimens made from mechanically produced powder. The results of mechanical tests indicate that sintered parts made from iron powder produced by reduction are stronger than those made from mechanically produced iron powder. Tables 1.

Flexible Planning System for Machining Plant

917F0093A Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 10, Oct 90 pp 3-5

[Article by A.D. Chudakov, candidate of technical sciences, V.G. Sharov, candidate of physical and mathematical sciences, and B.Ya. Falevich, candidate of physical and mathematical sciences, Scientific-Industrial Association "NIITavtoprom" ("Automobile Industry's

Scientific Research Institute of Technology") and Rybinsk Institute of Aviation Technology]

UDC 658.512.6.011.56

[Abstract] An adjustable universal standard system for automatic planning of operations and schedules in a diversified production plant has been developed by NIITavtoprom and the Rybinsk Institute of Aviation Technology, the principal advantage of this "Avtoplan" system being its usability for various different production process configurations. This advantage is realized by adjusting the software to the specific numerical values of the parameters which characterize the given production segment prior to activation of the planning system. This adjustment is done in two steps: first to maximum attainable numerical characteristics of a given process while the programs are generated, then to the parameters of the corresponding production line segment while the source database is formed. The system is an interactive one designed for use of a SM 1420 minicomputer with an RV operating system and programs written in FORTRAN-4. It contains over 10,000 operators and solves two management problems: 1) preliminary planning of the production run for three months ahead before the beginning of each month, 2) planning and documenting all instructions and assignments for each shift before the beginning of each work day. The production parameters are classified into five groups: 1) constants which characterize the plant structure, 2) constants related to technological routes available, 3) a constant which determines the assignment of work stations to a given work shift, 4) constants which prescribe the size of files and database, 5) constants which relate the numerical characteristics of a production line segment to size identifiers. The applied program package contains 10 groups of programs: 1) generating the database, 2),3) data input for daily and monthly access cycles, 4) generating data on the current status of not yet completed production, 5) preliminary planning, 6) scheduling the operations, 7),8) formulating and documenting the produced plan, 9) evaluating the schedule, 10) auxiliary service programs for interaction with the database.

Polymers: Dynamic Properties

917F0092J Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 27-28

[Article by I.I. Perepechko, V.V. Nizhegorodov, and I.G. Oshrina, Moscow Institute of Automotive Mechanics]

UDC 629.113-036.5

[Abstract] Use of polymers by the automobile industry is examined, there being a need to more carefully match their mechanical properties with the requirements for specific applications. Their static mechanical properties are not an adequate criterion for their suitablity, because cyclic alternating forces act on them while the engine runs so that their dynamic properties become the overriding criterion. In addition to being conventionally tested for tensile strength under a gradually increasing load, they must therefore also be tested for such properties as impact strength and toughness, dynamic modulus of elasticity, stability, vibration damping, mechanical losses in the vitreous state, and secondary peak intensity of mechanical losses over the entire operating temperature range. Polymers combining all desirable properties are rare, on the contrary: those having a high dynamic modulus of elasticity and a high impact strength do not, as a rule, readily dissipate mechanical energy and vice versa. For this reason, automotive polymer materials are usually mixtures of polymers excelling in a different dynamic property each. Typical examples are Noryl (polyphenylene oxide + high-impact polystyrene), glass-filled for additional strength, and Xenoy (polyethylene terephthalate + polybutylene terephthalate, both partly crystallized), each having been tested at the Moscow Institute of Automotive Mechanics and found to be eminently suitable for automotive applications. More affordable other polymer materials already available for automobiles still need to be evaluated, acoustical testing methods being most expedient for this purpose in terms of speed and accuracy. In the study S.P. Rozhkova participated.

NIITavtoprom (Automobile Industry's Scientific Research Institute of Technology) and Development of Powder Metallurgy

917F0092M Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 30-31

[Article by Ya.M. Gendlin, candidate of technical sciences, and V.S. Ivanov, candidate of technical sciences]

UDC 621.762:629.113.002

[Abstract] Following the groundwork laid by NIITavtoprom (Automobile Industry's Scientific Research Institute of Technology) since 1946 in development of powder metallurgy, from design of technological processes and application engineering to full-scale production setup, automotive parts made of metal powder are now produced at individual manufacturing plants. The Moscow Powder Metallurgy Plant produces about 100 items, including valve guides and valve rings. The Dnepropetrovsk Automotive Equipment Plant produces over 150 items, including intricate and very intricate parts of grade 8-9 precision for trucks and passenger cars. The Volzhsk Automobile Plant produces parts made of copper-base and iron-base materials for all VAZ models. The Gorkiy Automobile Plant produces 27 items for GAZ models. The Moscow Automobile Plant imeni I.A. Likhachev produces 20 items for ZAL models. The Kamo Automobile Plant will produce 70 items, including parts with spherical inside surfaces. NIITavtoprom has developed methods of compacting, sintering, alloying, and a thermochemical treatment applicable to

such materials as NAMI-GS-TAF and AG-NAMI, two materials for seals developed by the Scientific Research Institute of Automobiles and Automobile Engines (NAMI). Parts made of such materials are already mass produced on rotary lines which include high-productivity mixers, oil-impregnation equipment, and other special equipment. For the Industrial Association "Diesel Equipment" has been developed the technology for producing 20 items, 8 of them already being produced.

Ecological Diesel: Problems and Ways to Solve Them

917F0092E Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 17-18

[Article by A.P. Gusarov, candidate of technical sciences, L.M. Tartakovskiy, candidate of technical sciences, and T.R. Filiposyants, candidate of technical sciences, Scientific Research Center at Institute of Automotive Transportation and Scientific Research Institute of Automobiles and Automobile Engines]

UDC 629.43.6-62

[Abstract] The increasing shortage of liquid fuels, particularly diesel fuel, has stimulated both search of alternate fuels and development of combustion engines running on those fuels. Natural gas being the preferred substitute for diesel fuel, a diesel engine able to operate on diesel fuel alone and on natural gas with a certain amount of diesel fuel has been therefore developed at the Kamo Automobile Plant jointly with the Scientific Research Institute of Automobiles and Automobile Engines (NAMI) and the Scientific Research Center at the Institute of Automotive Transportation (NITsIAMT). Almost ready for production at the Kamo Automobile Plant are KamAZ-53208 and KamAZ-53218 pickup trucks, KamAZ-54118 truck-tractors, and KamAZ-55118 dump trucks, each built with such an engine. When running on gas, it not only uses up to 80% less diesel fuel than a conventional diesel engine but its exhaust is much cleaner, owing to a substantially lower fume content. Particularly significant is the lower concentration of solid particles and polycyclic aromatic hydrocarbons in the engine exhaust. However, the concentration of gaseous pollutants (CO, C_mH_n, NO_x) is much higher than when the engine runs on diesel fuel alone and especially so at top crankshaft speeds or under light loads. There is evidently not sufficient time for complete combustion of methane, the principal component of natural gas. Inasmuch as methane is nontoxic, it may be disregarded in gaging the exhaust contents against emission standards. The combined level of other hydrocarbons and NO_x gases then becomes comparable with that in the exhaust from a conventional diesel engine. The concentration of carbon oxide is higher than that in the exhaust from a conventional diesel engine, but lower than in the exhaust from a carburetor engine. It appears reasonable to modify the emission standards for engines running on the gas-diesel cycle accordingly. In the study participated S.V. Fuchkin at the Kamo Automobile Plant. Tables 2.

Construction and Composite Technical Indicators of Motor Transport Vehicles

917F0092D Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 15-17

[Article by A.A. Tokarev, doctor of technical sciences, Scientific Research Institute of Automobiles and Automobile Engines]

UDC 629.113.001.03

[Abstract] For an evaluation of the effectiveness of motor vehicles as means of transportation, several composite technical indicators are proposed as criteria facilitating an otherwise problematic comprehensive design and performance analysis. Considering that fuel consumption and productivity are the two principal factors determining the normalized cost, influencing it in opposite ways, selection of a vehicle must be based on a tradeoff as long as a vehicle which combines maximum productivity with minimum fuel consumption does not exist. One composite indicator helpful as criterion for selection can be the specific productivity (t.km/kWh), a rather universal parameter which combines load carrying capacity, speed, and fuel economy. Another such indicator can be the nominal energy efficiency, ratio of the useful work done in moving a load at average speed to the mechanical equivalent of heat generated by complete combustion of the fuel in the process. A refinement of this indicator would be expressing the useful work as twice the product of the load mass by the average speed squared (assuming that the acceleration time in a conservative system is equal to some travel time at average speed in a nonconservative one) and expressing that mechanical equivalent of heat as the product of the fuel consumption (volume x specific gravity) by the lower caloric value of the fuel. Both indicators are based on an arbitrarily 120 s travel time by passenger car and 210 s travel time by bus or truck. The expediency of these composite indicators is demonstrated on a design and performance evaluation of diesel trailer trucks, buses, and passenger cars. A third composite indicator can be the ratio of the productivity (t.km/kWh or passenger.km/kWh) to the power equivalent of heat generated by complete combustion of the fuel. This indicator is, for illustration, used for comparing a ZIL-130 (Moscow Automobile Plant imeni I.A. Likhachev) truck transporting 5 tons at 60 km/h with a ZIL-4331 truck transporting 6 tons at the same speed, the ZIL-4331 being more effective in terms of a 48% higher hourly productivity (3.7 t.km/kWh). In the same manner are compared PAZ-3205 (Pavlovo Autobus Plant) and LAZ-695N (Lvov Autobus Plant) buses carrying passengers at 60 km/h, the LAZ-695N being more effective in terms of a

39% higher hourly productivity (27.3 passenger.km/kWh). A comparison of two Likino Autobus Plant city buses, the LiAZ-677 with a gasoline engine and the LiAZ-5256 with a diesel engine, indicates that the LiAZ-5256 is more effective in terms of a 60% higher hourly productivity (49.6 passenger.km/kWh) when carrying 110 passengers at 60 km/h, owing largely to the much better fuel economy: diesel fuel 23 liters per 100 km and gasoline 40 liters per 100 km. Tables 1.

High-Productivity Hobs

917F0092I Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 p 27

[Article by A,M, Goncharov, Yu.A. Derkach, and S.S. Malov, Kremenchug branch of Kharkov Polytechnic Institute and Kremenchug Automobile Plant]

UDC 621.914.6

[Abstract] The problem of increasing the productivity hobs without shortening their life is shown to be solvable by design optimization. This involves optimizing the positive back rake angles and curvilinear corrective sharpening along the leading tooth surface. Hobs made of R6M5 high-speed tool steel, all with a 100 mm outside diameter and a 12° initial profile angle of the main worm but with different cutting wedges were tested for a comparative design and performance evaluation. The results indicate that hobs with a 15° lead angle have a longer life than those with a 0° lead angle and corrective sharpening. The life of those with a 0° lead angle was, moreover, shorter at a 1.67 mm/rev feed rate than at a 2.53 mm/rev feed rate. The cutting torque of all hobs decreased as the feed rate was increased, less when the lead angle was 15° but after corrective sharpening more than when the lead angle was 0°. The hob performance was found to also depend on the amplitude the hob torque fluctuations, this amplitude being 10-25% smaller with a 15° lead angle than with a 0° lead angle. With a 15° positive lead angle and curvilinear corrective sharpening of the leading tooth surface, a cutting speed of 50.4 m/min and a feed rate of 2 mm/rev have been found to ensure a tool life of 180 min and a tool wear not exceeding 1 mm.

Diamond Honing of Cylinder Liners

917F0092H Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 26-27

[Article by V.F. Romanyuk, candidate of technical sciences, Chelyabinsk Institute of Farming Mechanization and Electrification]

UDC 621.923.5:621.921.34:621.43-223.002.2

[Abstract] A device has been built for honing casehardened cylinder liners which combines use of an abrasive diamond stone with ultrasonic treatment. Ultrasonic vibrations in planes perpendicular to the liner axis of rotation in the process prevent the stone from becoming increasingly greasy or dirty and thus a degradation of its microcutting capability. The vibratory system consists of a magnetostrictive transducer which converts electrical oscillations into mechanical vibrations and a concentrator to which the holder with abrasive stones is stuck. Experiments have confirmed theoretical estimates, namely that 18-24 kHz vibrations with amplitudes within the 5-10 μm range cause the contact between individual diamond grains and the liner surface 4-5 times longer and the instantaneous velocity of grains to become 3-4 times higher. Not only is the productivity of the microcutting process thus increased by a factor of 2-3 but also its precision is improved and a finer surface finish is obtained. Experiments were performed with ASM40/28M1 100% diamond stones and cylinder liners made of alloy cast iron quenched to HRC 42-50 hardness, for a study concerning the dependence of the honing process characteristics on the vibration amplitude as well as on the diamond grain size and on the physical forces involved. Neither the rotational motion nor the reciprocating motion of the toolhead were varied, its peripheral velocity of rotation and its linear travel remaining fixed at 66 m/min and at 8.1 m/min respectively, with the radial feed also held constant at 18 μm per double stroke. Particular attention was paid to adhesion after seizure of diamond grains by the liner material, to the resulting adhesive as well as abrasive wear, to the profile angle, to the rate of material removal from the liner, and to the final liner surface finish. The data indicate that ultrasonic treatment improves the performance of diamond stones so much that speeding up the rotation of the hone to 100 m/min and also speeding up the radial feed becomes feasible. The reciprocating motion of the hone has been found not to significantly influence the shaving rate and thus the productivity of this machining process.

New Circular Broach for Machining Gears

917F0092G Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 24-26

[Article by D.I. Popov, candidate of technical sciences, and P.Ye. Yelkhov, candidate of technical sciences, Moscow Institute of Automotive Mechanics]

UDC 621.833.002.2:621.919.2

[Abstract] Teeth of spur gears are now generated by means of a milling or circular-diagonal broach, each with rough-machining and fine-machining cutter segments. The resulting shape of the tooth depends largely on the cutter profile as well as on the cutter hardness and on the machine tool setup. An analysis of the cutter-gear configuration and the machining operation indicates that the cutter profile can be simplified to a degree depending on the required gear precision class. It can be made to form an arc of an ellipse, an arc of a circle, or a

composite of arcs with different radii each. The cutting process will, furthermore, be improved and roughness of the tooth flank surfaces be reduced when the leading surfaces of the fine-machining cutter segments have been additionally sharpened along a curving surface which will match the shape of curling chips of the gear blank. Studies have shown that the productivity of cutting spur gears with circular broaches to a 6-7 precision class is 2-3 times higher than cutting them with hobs and will generate tooth flanks with a surface roughness not exceeding the Ra = 2-3 μm range. Figures 3.

Asbestos-Free Plastic For Friction Pairs

917F0092L Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 29-30

[Article by Ye.B. Trostyanskaya, doctor of technical sciences, G.M. Reznichenko, and Z.M. Shadchina, candidate of technical sciences]

UDC 629.113-03:621.891

[Abstract] A plastic material FBP has been developed by the Moscow Institute of Aviation Technology which does not contain asbestos fibers but has excellent mechanical and thermophysical properties needed for friction pairs. Its coefficient of friction is higher and its wear intensity index (μg/J) is lower than those of the asbestos-reinforced commercial FK-16L with resin binder and 6KKh-1B with rubber binder at temperatures up to and above 400°C (only the FK-16L has a higher wear intensity index at 500°C). Being a Class-5 material (wear intensity 0.25 μg/J at 100°C and 0.44 μg/J at 400°C), it is eminently suitable for brake linings. These and other automotive parts are produced in molds at 160-170°C temperature under 18-22 MPa pressure, holding time 3 min per 1 mm thickness. The production cost of a set of four FBP brake linings for the GAZ-24 (Gorkiy Automobile Plant) "Volga" car is 72 kopeks. Other characteristics of this material are: hardness HB 30, density 2100-2200 kg/m^3, strength 36-90-50-36 MPa (tensile, compressive, flexural, shear), flexural modulus of elasticity 5.3 GPa, toughness 8.5 kJ/m^2, thermal shrinkage 0.2 %, deflection temperature (Martens) 190°C, water, oil, and gasoline absorption 0.04 %, 0.06 %, and 0.06 % in 24 h. Figures 2; tables 2.

Means of Transportation for Northernmost Regions

917F0092A Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 8-10

[Article by Z.L. Sirotkin, doctor of technical sciences, and V.I. Kotlyarenko, Scientific Research Institute of Automobiles and Automobile Engines]

UDC 629.113(211)

[Abstract] The problem of automobile design and construction for transporting passengers and goods in northernmost regions of Siberia and the Far East is examined on the basis of socioeconomic projections coming from the Siberian Department (Yakutsk branch) of the USSR Academy of Sciences. The engineering aspects of the problem are emphasized, technical requirements and specifications for a "northern" automobile operative at temperatures from +40°C to -60°C and at up to 98% humidity, during polar nights, and without garage facilities, having been established on the basis of studies made at the Scientific Research Institute of Automobiles and Automobile Engines and the Scientific Research Center at the Institute of Automotive Transportation. The key items vulnerable at low temperatures are the electrical system, especially the battery, the lubrication system, the windhsield, and the other windows. Essential requirements for their maintenance are suitable materials, adequate heating, and thermal insulation necessary to ensure safe, reliable, and comfortable driving. Batteries with built-in electric heaters and with automatic electrolyte temperature regulation are already produced for several automobile plants (Kamo, Minsk, Kremenchug, Ural), but the volume is still low so that utilization of the engine exhaust heat remains standard practice and this precludes heating of the battery when the engine is shut off. Another innovation are liquid heaters PZhD and PZhB generating 5,200-60,000 kcal/h for preheating the engine before starting. Electrically heated glass windows are already being installed in KrAZ (Kremenchug Automobile Plant), BelAZ (Belorussian Automobile Plant), and other cars. Felt sealing of passenger car floors should be replaced with removable floor mats made of foam polyethylene or foam polyurethane. Development of a universal lubricant fluid suitable for diesel and carburator engines is to be now developed, along with a variety of special additives to a basic "slow-cooling" motor oil. The Kremenchug Automobile Plant will produce three-axle full-drive trucks with 235 kW (319 hp) engines and single-ply tires on all wheels, 25-ton semitrailers, 48-ton truck-tractors with two-ply tires on the rear wheels, and 15-ton dump trucks with 206 kW (280 hp) engines. At the Gorkiy Automobile Plant have already been built prototypes of "northern" vans on GAZ-666 (Gorkiy Automobile Plant), ZIL-131 (Moscow Automobile Plant imeni I.L. Likhachev), and KamAZ-4310 (Kamo Automobile Plant) chassis for transporting perishable goods, with controlled heating which maintains the inside temperature at +8°C at -60°C outside temperature and with reinforced thermal insulation. At the Neftekamsk Automobile Plant is planned production of fuel tenders on MAZ-7310 (Moscow Automobile Plant imeni Lenin Komsomol) chassis carrying a 24,000-liter tank. The Minsk Automobile Plant already produced heavy-load tandem trailer trucks consisting of a tractor with a 478 kW (649 hp) engine and two three-axle semitrailer platforms with 75 tons and 100 tons capacity

respectively. All these vehicles must meet applicable emission standards so as not to destroy the tundra vegetation.

Self-Lubricating and Self-Hardening Piston Rings

917F0092F Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 18-19

[Article by A.I. Kulikov, candidate of technical sciences, V.Ya. Gureyev, and V.A. Burdyga]

UDC 621.43-242.3

[Abstract] Increasing the heat, wear, and corrosion resistance of piston rings by phosphating is proposed, this method being more effective and reliable than chromizing, tinning, or lubricating with molybdenum disulfide. The hardness of the surface layer is then increased by iron phosphide, which together with cementite and phosphor-enriched austenite forms a ternary eutectic with a 950°C melting point. The phosphating process involves passivation in an AKhFS or MIKS solution, both containing aluminum and chromium so that phosphides of these metals are formed as well, and subsequent heat treatment. The method is very economical and does not require as fine a surface finish as does chromizing. Furthermore, a "self- lubricating" antifriction layer not wettable by oil forms on the surface after passivation so that fewer scraper rings are needed. The thickness of the passivation film depends on the passivation temperature and time, also on the AKhFS or MIKS binder concentration. Conventional subsequent heat treatment is, however, necessary for case hardening. It may be possible to eliminate this treatment, inasmuch as piston rings usually operate at temperatures close to the heat treatment temperatures and will therefore be hardened anyway. The equipment for phosphating is conventional, preferably set up to form a readily mechanized and automated flow line but with a closed water supply system so as to prevent contamination of the environment. Figures 1; tables 1.

Fumes in Diesel Engine Exhaust During Idling: Solvable Problem

917F0092B Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 10-12

[Article by M.Kh. Veynblat, candidate of technical sciences, and P.A. Fedyakin, Industrial Association "Turbomotor Zavod" (Turbine Engine Plant)]

UDC 621.436.068

[Abstract] A study of DM 21 (ChN 21/21) 12-cylinder diesel engines conducted at the "Turbomotor" Plant has revealed that the fume content in the engine exhaust during idling increases with increasing crankshaft speed first slowly from 5-7% at 700 rpm to 10-12% at 1100 rpm and then rapidly to 50% or higher at 1545 rpm. While the initial slow increase is obviously caused by a decrease of excess air owing to a faster cyclic fuel injection, the subsequent rapid increase has been found to be caused by an increase of the fuel-to-mixture ratio owing to the higher fuel injection rate at higher speeds. The injection process can be divided into two stages: after the priming squirt a quasi-continuous injection, the needle having been lifted owing to elastic deformation of nozzle elements at speeds up to 1100 rpm, and a subsequent injection at a periodically oscillating rate which peaks when the spring force on the needle dips owing to vibration of the spring coil. Oscillograms of the fuel pressure before the throttle indicate two pressure pulses occurring when the high-pressure fuel pump rotates at a speed higher than 450 rpm: a main pulse generated by the pump piston and a second pulse generated by a wave process in the high-pressure pipe. This second pulse originates somewhere within 200-400 mm from the fuel pump nozzle when the first pulse arrives here and the resulting hydraulic shock breaks the continuity of the fuel jet. On the basis of these findings and further analysis of the entire fuel delivery process, it appears that the fume content in the engine exhaust at top idling speed can be reduced from 60% to 20% by preventing fuel jet discontinuity in the high-pressure pipe. One way to achieve this is to raise the fuel pressure in the feed line to 0.5 MPa. Another way is to equip the high-pressure fuel pump with corrective valves. Figures 2.

Wear-Resistant Cast Iron for High Temperatures

917F0092K Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 28-29

[Article by M.P. Shebatinov, I.P. Mardykin, and P.P. Sbitnev, Moscow Institute of Automotive Mechanics]

UDC 669.15-195.5

[Abstract] As a result of an extensive theoretical and experimental study, four new grades of alloy cast iron have been developed by the Moscow Institute of Automotive Mechanics which feature a high wear-resistance at 310-760°C temperatures in addition to the basic properties of cast iron desirable for automotive applications. All contain 3.2-3.4 % C, 2.1-2.3 % Si, 0.06-0.1 % P, 0.07-0.1 % S. Grade No 1 contains 0.6 % Mn, 0.1 % Ni, 1.2 % Cu, 0.2 % Mo, 0.1 % Cr, 0.2 % V. Grade No 2 contains 0.68 % Mn, 0.1 % Ni, 1.5 % Cu, 0.13 % Cr. Grade No 3 contains 0.53 % Mn, 0.01 % Ni, 0.15 % Cr. Grade No 4 contains 0.76 % Mn, 0.02 % Ni, 0.6 % Cu, 0.14 % Cr, 0.15 % V. The key alloying elements are Mo, Cu, V, inasmuch as they increase the wear resistance appreciably and maintain it under loads of up to 200 MPa, while also maintaining both the high strength and the hardness at temperatures up to 700°C. Addition of Ni and Si facilitates graphitization and consequently lowers the solubility of carbon in the austenite, Ni in low concentrations stabilizing the pearlite and in higher

concentrations increasing its dispersion. Addition of Cu inhibits formation of cementite and consequently enhances structural uniformity. Addition of Mo and V retards the growth of primary grains and ultimately limits their size to a sufficiently small one. All alloying elements, except Si, facilitate the austenite → pearlite transformation. Pearlite formed at lower temperature is more highly disperse and consequently more wear resistant, harder, and stronger. Its formation at lower temperatures is facilitated by those alloying elements, while formation of the much less desirable ferrite is inhibited. Tables 2.

Performance Characteristics of Diesel with Turbosupercharger in Mountainous Environment

917F0092C Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 9, Sep 90 pp 14-15

[Article by E.V. Aboltin, candidate of technical sciences, and V.M. Kurbatov, Scientific Research Institute of Automobiles and Automobile Engines]

UDC 621.436.052:113(23)

[Abstract] The performance of a diesel with a turbosupercharger in a mountainous environment was studied in a laboratory test stand simulating the conditions at altitudes up to 3500 m, specifically the correspondingly decreasing air density and pressure. For this study, made at the Scientific Research Institute of Automobiles and Automobile Engines (NAMI), an 8ChN13x14 diesel engine was supplemented first with a commercial K-36 turbosupercharger and then with the TKR-9 NAMI experimental one, the latter operating at about the same 57% efficiency but its turbine with a 15% lower throughput capacity providing 10-20 kPa more supercharge. The crankshaft speed was varied within the 1000-1600 rpm range only, this being the range of normal diesel operation in mountains and of most appreciable attendant degradation of its performance. As the engine was "climbing" from sea level to 2000 m and then 3000 m altitudes while running at 1000-1200 rpm crankshaft speed, the specific fuel consumption was increasing (3-5% higher at 2000 m, 4-7.5% higher at 3000 m) and the gas temperature at the inlet to the supercharger turbine was rising (60-80°C higher at 2000 m, 95- 105°C higher at 3000 m). With the engine thus "climbing" while running at 1400 rpm or higher crankshaft speed, the specific fuel consumption increased less (only by 3%) at 2000 m and as much (4-7.5%) at 3000 m. This is attributable to higher initial excess air ratios at 1400 rpm and higher speeds. The results indicate that 3000 m is the highest altitude to which this diesel engine may climb, inasmuch as the 720°C gas temperature at the turbine inlet already exceeds the maximum 650°C and 700°C allowed by the All-Union Government Standard 9658-81 for continuous and up to 1 h long intermittent operation respectively. Tests were also performed on a modification of the 8ChN12x12 diesel engine with a very low, only 1.4, initial excess air ratio. Here the mean effective pressure and the specific fuel consumption were found to be still more altitude-dependent. On the basis of these findings, it is recommended that a "mountain" diesel engine operate with a supercharger whose turbine has a 15% lower than base throughput capacity and with a not smaller than 1.8 excess air ratio at sea level. Tables 1.

Tool Production Is Gaining Momentum

917F0091K Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 p 31

[Article by S.A. Gusev]

UDC 658.563

[Abstract] Toolmaking for the automobiles industry is keeping up not only with latest improvements in machine tool operation such as numerical program control and in flexible production systems including multipurpose equipment but also with development of new materials for tools such as tungstenless hard alloys and new materials for automobile parts such as plastics and composites. Punches made of foam concrete and punches made of various composite or fusible materials by casting are already available for small-scale production of some automobile parts. A vacuum film deposition technology, a gaseous-phase case hardening technology, and various electrophysical process are becoming available for large-scale tool production. Priority has been assigned to ion-plasma deposition of wear-resistant coatings on cutting tools, a new machine for hardening large tools by this method being now designed at the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom). A program has been devised for speeding up the comprehensive development of tool production for the 12th five-year plan period, production of special large milling machines for crankshafts having already been set up at the Kamo Automobile Plant to meet the needs of this and other automobile plants. The prototype of an electrochemical treatment apparatus is being built at the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom) which will treat the working surfaces of large dies and punches with an 85% labor saving. A production lot of milling machines has already been built for profiling punches by pattern tracing precisely within +–0.03 mm.

Technology and Reliability of Heavy-Duty Gears

917F0091C Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 13-14

[Article by V.A. Olovyanishnikov, candidate of technical sciences, B.V. Georgiyevskaya, candidate of technical sciences, and V.V. Kuznetsov]

UDC 621.785.5:629.113-585.2-192

[Abstract] Application of the new carburizing and carbonitriding processes with program regulation of carbon and nitrogen potentials, developed at the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom) for case hardening of automotive parts has not met expectations with regard to strength, stability, and life of the surface layer under static and cyclic loads. A study was therefore made concerning the premature failure of gears, particularly vulnerable being driver and driven pinions of the main gear set in UAZ (Ulyanov Automobile Plant) cars and also shafts and pinions in the transmission box of YaMZ (Yaroslavl Automobile Engine Plant) diesels. The results have revealed that the static flexural strength and the fatigue strength of pinions made of 23CrNi2Mo or $15CrMnNi2TiN_2$ steel depend principally on the effective case thickness along the tooth flanks, on the microhardness of the tooth crown, and on the degree of its microstructural uniformity. With pinions made of 23CrNi2Mo steel the maximum strength steel was attained with a 0.6-0.8 mm case thickness and a 350-390 H50 tooth crown microhardness. With pinions made of $15CrMnNi2TiN_2$ steel the maximum strength was attained with a 0.9-1.0 mm case thickness and a 360-380 H50 tooth crown microhardness. Variation of the microhardness served as indicator of microstructural nonuniformity, a variation of not more than 25-30 H50 leading to pure ductile fracture and a variation as wides as 70-80 H50 leading to predominantly brittle fracture. Two dimensionless parameters have been introduced for estimating the life of pinions. The life estimator based on strength, its optimum value being 3-3.5, combines the influence of all three relevant factors (case thickness, microhardness, degree of microstructural uniformity). The life estimator based on wear combines the influence of those three factors with the influence of the residual austenite content, on which the wear of pinions has been found to also strongly depend. Its optimum value is 5-6 (50 h of contact). The study was made under scientific guidance of V.M. Zinchenko, candidate of technical sciences. Tables 1.

Dimensional Finish Treatment Gives Engine Parts New Qualities

917F0091E Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 15-16

[Article by V.I. Kartsev and A.E. Isakov]

UDC 621.923.5:629.113.002.2

[Abstract] NIITavtoprom (Automobile Industry's Scientific Research Institute of Technology) has developed superfinish treatment of engine parts with kinematic closure of the "tool bit - workpiece" system for removal of defective surface layers after grinding, such a treatment not only being more economical than optimization of the entire grinding process but also resulting in a higher dimensional precision and longer life of finished parts. The equipment includes special buffs built into multiple-bit heads of machine tools, predominantly imported ones, for such operations as finish treatment of crankshaft fillets, cylinder liners, piston rings now made of narrow steel strip, and other precision parts. These machine tools operate with automatic control, with regulation of the lubricant-coolant fluid feed, and with thorough removal of chips. Superfinish of cylinder liners for longer life by conventional and unconventional methods is being studied, one of them being the FABO method: rubbing the cylinder mirror surface with an abrasive material which will improve the run-in. Another method is hard honing with a floating tool. These methods with suitable tooling will need to be adapted for finish treatment of parts either made of better ceramic materials or with coatings of more wear-resistant materials, as such materials become available. Figures 2.

Automatic Instruments for Nondestructive Inspection

917F0091J Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 28-91

[Article by Ye.A. Samchenko and O.M. Skvartsova]

UDC 620.179.629.113

[Abstract] NIITAvtoprom (Automobile Industry's Scientific Research Institute of Technology) has developed a large class of special-purpose automatic and semiautomatic instruments for nondestructive 100% factory inspection of automobile parts. They include the "Indefekt" series of highly reliable universal magnetoluminescent flaw detectors for detection of surface defects in parts made of ferromagnetic materials with up to 250 mm large diameters and various degrees of surface roughness. These instruments use special ultraviolet lamps as radiation sources, shielded from daylight, and emulsions of magnetoluminescent powder or paste for luminescent display panels. The basic model "Indefekt-1289" is designed for circular magnetization with a current of 2 kA, for longitudinal magnetization to a 30 kA/m field intensity, and for compound magnetization. It draws a power of 10 kW and weighs 600 kg. Two of them have been installed in the inspection station at the Volzhsk Automobile Plant for detection of surface defects in connecting rods. These highly automated instruments operate with a demagnetizer consisting of a 30 A - 50 Hz coil in a frame through which the conveyor belt with connecting rods passes. A light is automatically turned on as a connecting rod passes under the frame, to indicate that it is being demagnetized. A similar automatic inspection station is being prepared for crankshafts of passenger car engines. At the same time there are also being developed instruments for nondestructive structural examination by the eddy-current method, namely the "Indeterm" series with PIKOT indicators for

quality control of heat treatment of cast iron, steel, and cermet parts 7-150 mm in diameter with an at least 3:1 length-to-diameter ratio. An automatic "Indeterm-1279" has been installed at the Gorkiy Automobile Plant for quality control of heat treatment of six different fastening bolts. The semiautomatic "Indeterm-1287" is intended for quality control of heat treatment of gage and stud bolts for tractor diesel engines. Figures 5.

NIITavtoprom's Low-Scrap Forging and Pressing Technologies

917F0091F Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 18-19

[Article by I.A. Bykov and V.V. Nikiforov]

UDC 621.73:504.064.43

[Abstract] NIITavtoprom (Automobile Industry's Scientific Research Institute of Technology) has developed five new technological processes with proper automation, forging and pressing processes designed to minimize the amount of metal scrap. The first process is punching out parts like cam pins and bevel gears from rolled stock. The second process is mechanized scrapless casting of forge dies, using molds made of a special thermosetting mix. The equipment for this process includes an electric furnace for curing the molds, a mold shaking vibration table, and a few nonstandard accessories. The third process is punching out brass parts from cast blanks in an 8-position rotary casting and forging machine. The fourth process is cold drop forging, with an 80-95% material utilization, which will save 600-700 tons of metal and 120,000 kWh of electric energy per 1000 parts produced when it replaces cutting operations. The fifth process is punching from blanks of sheet metal by the stretch-and-wrap method, the blanks having a 20% smaller than conventional allowance and the parts being reproducible within tighter than conventional tolerances. All five processes have been designed for both high productivity and maximum metal economy. Figures 3.

Special Casting Methods Acquire Production Base

917F0091G Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 19,22

[Article by G.I. Boryakov, candidate of technical sciences]

UDC 621.74:629.113.002.2

[Abstract] A production base including equipment and automation for more productive and economical investment casting into dry or green molds with patterns "lost"by melting, burning out, or vaporization, also injection casting under low or high pressure, is being designed and tested at the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom). Four automated mold production lines are available, two for flask molds and two for open ones, all four yielding molds of at least one higher precision class with a 3-5% better metal economy than those now produced. Under consideration is also development of new mold mixes, with special additives which will improve flow and reduce brittleness, or with an argillo-concrete binder modifier which does not require a foam quencher. An antifriction lubricant fluid has been developed jointly with the All-Union Scientific Research Institute of Petroleum Reprocessing (Kuybyshev branch) so that external friction can be decreased and the productivity of molds increased by replacing with this SZh-9 lubricant the OK-72 now in use. A breakthrough in casting technology is the "kor-NIITavtoprom" process, namely casting "fishbone" blocks into a stack of dry molds made of thermosetting resins and produced by the "hot" method. The production line for this process includes an automatic 16-position machine with gas heating of the pattern die. Its 16 pattern plates on a continuously rotating table are heated to a temperature within the 260-300°C range. Full utilization of the mold mix is ensured by its regeneration in a fluidized bed after each casting operation, the recovered sand then being passed through the cooling system. This process is already used for production of automotive parts weighing up to 5 kg and for precision casting of steel forge presses weighing up to 500 kg. Another recent development is a technological process for casting ferrous and nonferrous alloys with patterns made of granular polystyrene foam and disposable by vaporization. These patterns are treated with a special fire-resistant gas-permeable paint and then dried before being placed into the mold flask and covered with quartz sand, the latter being compacted by vibratory action. Metal is poured into a mold without prior removal of the pattern, the latter evaporating in the process and being replaced by the metal which upon cooling forms an exact duplicate of it. Special automatic and semiautomatic equipment has already been installed for production of iron and aluminum castings. A precision casting process with use of wax patterns disposable by burning out has been developed jointly with the All-Union Scientific Research Institute of Casting Machines. This process is 30% more productive and 25-30% more economical than casting with patterns disposable by melting, the casting cycle being three times shorter and requiring a 20-30% smaller floor area. A low-pressure casting process using the 4188-OZMP semiautomatic machine has been developed jointly with the Zaporozhye Automobile Plant for production of aluminum cylinder heads. Transition of new casting processes from the experimental laboratory mode to the industrial production mode is thus well underway. Figures 2.

Automation of Assembly: Model MeMZ-245 Engine

917F0091I Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 25-26

[Article by G.V. Aksenov and B.V. Gusakov]

UDC 621.43.002.72:621.757.06-52

[Abstract] An automatic assembly line for the MeMz-245 (Melitopol Engine Plant) engine of the new ZAS-1102 (Zaporozhye Automobile Plant) passenger car with front-wheel drive has been developed and built by a joint effort of the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom), two offices of its Institute of Transportation Economics (MKTEI, GKTEI), and its Institute of Experimental Design and Manufacturing Engineering (EKTI). This assembly line is divided into four segments operating asynchronously. The first one is 50 m long and has 18 positions (14 of them automatic) for assembly of the engine block with cylinders, caps, sleeves, and pins, for stamping the engine identification number, for wash-and-dry operation, and for a subsequent leakage test. From here blocks which have failed this test are moved to a repair station and those which have passed it are moved to the second assembly line segment. This one has also 18 positions (12 of them automatic) for mounting the crankshaft with bearings, after a wash-and-dry operation, and for a subsequent axial clearance test. From here blocks with crankshafts which have failed this test are moved to a repair station and those which have passed it are moved to the third assembly line segment. This one is 38 m long and has 23 positions (13 of them automatic) for insertion of pistons, connecting rods, and packing glands, also for installation of the cooling system, the crankcase with oil, the flywheel, and the clutch. The fourth assembly line segment is 72 m long and has 34 positions (13 of them automatic) for connecting the engine to the transmission after the latter has been assembled and tested. The entire engine assembly is moved to a final test station. The assembly line has thus a total of 52 positions, to which are added 10 repair positions and 7 standby positions. Parts are transferred from one position to the next and from one line segment to the next by jigs built into the conveyor mechanism, by planetary jigs, and by automatic manipulators. Associated equipment includes, besides the washer-dryer set, an overhead tool suspended on balance beams. All operations requiring force or lifting are automated. The entire assembly operation is controlled with Siemens GmbH programmable monitors. Figures 2.

Technological Complexes "Under Contract"

917F0091A Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 8,10

[Article by V.I. Titov]

UDC 658.512

[Abstract] Setting up technological complexes, workshops, production lines, and factories "under contract" has been found to be the most effective way to develop any machine manufacturing industry including the automobile. The most difficult necessary task here is to quickly select the optimum solutions to engineering and management problems, which requires a highly qualified professional staff capable of assuming responsibility. This applies as well to technical and planning activities at the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom), whose staff participated in optimizing the construction of both Volzhsk and Kamo Automobile Plants, in reconstruction of and re-equipping both Moscow imeni Lenin Komsomol and imeni I.A. Likhachev Automobile Plants, the Gorkiy, Ulyanov, and Ural Automobile Plants, Likino Autobus and Kharkov Bicycle Plants, also the Kirgizian Automobile Engine Works. Teams of specialists at the Institute have contributed to the development of new diesel engines for passenger cars, for trucks, and for tractors at the Ufa and other Engine Plants. They have also taken part in developing and setting up automated technological complexes for precision casting at both Moscow imeni I.A. Likhachev and Gorkiy Automobile Plants, also at the Irbit Motorcycle Plant, for cold extrusion and drop forging at the Kamo Automobile Plant, for plasma-jet case hardening at the Melitopol Engine Plant, for assembly and testing of high-pressure fuel pumps at the Yaroslavl Fuel Handling Equipment Plant, for assembly and welding of car and tractor wheels at the Kremenchug Automotive Wheel Plant and at the Chelyabinsk foundry, for reprocessing paint and varnish scrap at several automobile plants, for MeMZ-245 engine assembly at the Melitopol Automobile Plant, and for arc welding, painting, and other operations at various plants. This vast experience has demonstrated the feasibility of producing new technological complexes up to twice as more efficiently "under contract" than by traditional methods, completion of a project taking only 3-4 years instead of the 10-15 years taken until now.

Welding: Toward New Higher Technical Level

917F0091H Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 23-25

[Article by V.I. Mitin, candidate of technical sciences, G.M. Alekseyev, candidate of technical sciences, and N.A. Kondrashova]

UDC 621.791:629.113.002

[Abstract] One of the development programs at the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom) is aimed at improvement of the welding process in terms of productivity, economy, and product quality. This program covers three areas: 1) automation and robotization, 240 automatic assembly-welding lines and 540 welding robots

being already in operation, 2) electron-beam and laser-beam welding, these processes having already been semi-automated, 3) special welding methods such as friction welding. Developments in these areas are spilling over to other manufacturing processes as well. Specific examples of this are surface hardening by laser-beam heat treatment and cutting with an air-plasma jet. The inside surfaces of cylindrical holes are with the holes in a horizontal position, this operation being done by a flexible technological laser module. Tubes and also tubular blanks for semitrailer are cut with an air-plasma jet at the Krasnoyarsk Automobile Plant. Another process, developed jointly with the Voroshilovgrad Institute of Machine Construction Planning and Technology, is electric-spark surface hardening or coating of tools and parts. This is done in air without deep heating and without special surface preparation, after conventional thermochemical or plain heat treatment. A laser holographic interferometer has been designed and built at the Automobile Industry's Scientific Research Institute of Technology for quality control by on-line inspection of residual stresses after welding or any other operation. In this state-of-the art survey participated V.Ye. Driker. Figures 1.

Turbocompressor Runners Are Becoming Better

917F0091D Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 14-15

[Article by B.A. Pepelin]

UDC 621.436.031.3-192:621.74.045

[Abstract] Considering that the performance characteristics of an internal combustion engine which include power, fuel consumption, and pollutant level in the exhaust gas depend largely on the turbocompressor performance and thus on the quality of the runner, a comprehensive development and design activity is underway at the Automobile Industry's Scientific Research Institute of Technology (NIITavtoprom) aimed at improving the technological processes and equipment necessary for economical production of high-grade runner wheels. Turbine wheels, which are made of heat-resistant alloys, can already be produced by a better method of precision casting by the lost wax method into permanent molds under vacuum without crucible. This process is 2-3 times more energy-efficient and up to twice as productive in terms of fewer rejects than conventional precision casting with crucible. It requires much smaller smelters and no moving parts so that the operation is simpler and the vacuum much more stable. The precision casting process developed for compressor wheels, which are made of an aluminum alloy, involves elastic rubber patterns and permanent rather than split plaster of Paris molds. Figures 1.

Laser Increases Reliability of Automobile Transportation Equipment

917F0091B Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 8, Aug 90 pp 10-12

[Article by B.F. Mulchenko, candidate of physical and mathematical sciences]

UDC 629.113.002.2:621.375.826

[Abstract] Technological lasers are used in automobile plants not only for welding and cutting but also for case hardening: the inside surface of cast-iron cylinder liners, blocks, and heads at the Moscow imeni A.I. Likhachev and Kamo Automobile Plants, crankshafts at the Yaroslavl Automobile Plant, keyways at the Kremenchug and Ural Automobile Plants, around the holes in mounting brackets at both Belorussian and Minsk Automobile Plants, and parts of the steering wheel at the Belorussian Automobile Plant. While the laser technology has greatly contributed to a better quality of automotive parts, domestically produced conventional gas lasers and even the latest line (TL-1.5, TL-5, LN-2.5NM-I1, MTL-2, Lantan- 2/3) are not sufficiently economical for use in this industry on account of their high metal content as well as high price and high operating cost. The economics of laser technology in the automobile industry will gradually improve, however, as special continuous-wave and pulsed solid-state lasers are being developed. Production of such lasers within the 300-400 W power range has already begun and experimental prototypes of more powerful lasers in the 1 kW and higher range have already been built. The advantages of these lasers over gas lasers are not only smaller size and lower operating cost but also better adaptability to cutting thin sheet of any material. Use of these lasers for welding, cutting, hardening, and alloying will not only increase the labor productivity but also improve the reliability of parts and thus lengthen the life of the automobile. It will also stimulate new design activity and use of less costly new materials. One example of a novel concept for diesel passenger cars discussed at the Ulyanov Automobile Plant is alloying the metal of each engine piston along its groove for the first compressor ring. Figures 5.

Light-Weight Die Forged Blanks

917F0090E Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 7, Jul 90 pp 24-25

[Article by A.M. Smurov, Scientific-Industrial Association NIITavtoprom (Automobile Industry's Scientific Research Institute of Technology)]

UDC 621.73.002.6

[Abstract] In connection with the continuing efforts by foreign automobile manufacturers to reduce the weight of automotive parts, by use of light materials and less

massive stock such as tubes instead of rods, new methods of precision die forging have been developed which involve special flexible tools with automatic control and an attendant changeover from large-scale to medium-scale and small-scale parts production. Achievements in this area were demonstrated at the exhibition in Hannover (Germany), where hot forged and half-hot forged blanks weighing very little more than the finished parts with functional surfaces requiring very little or no further machining were shown. One of them was a steel blank of a segmental flange weighing 420 g (30% less than a conventionally forged blank) for a diesel fuel injector, with small corner radii and a punched hole. Another was a steel hub weighing 86 kg with a conical rather than cylindrical rod. Also cold extrusion is used by manufacturers abroad for producing blanks with minimum weight, this process however requiring several transfer operations. Hollow parts are now produced not only by hydroforming but also by high-precision radial forging. An ironware manufacturer in Michigan (USA) has recently introduced a half-hot forging process which involves use of closed dies and a constant-volume (within 0.7%) constant-temperature operation, for production of parts with the optimum macrostructure and with high dimensional precision including sharp corners. This process has been adapted for crossheads and other machine parts made of steel, aluminum, copper, brass, or titanium with wall thicknesses down to 2.4 mm.

Model LuAZ-1302 Superior-Roadability Passenger Car

917F0090A Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 7, Jul 90 pp 5-7

[Article by Ya.M. Robak, Lutsk Automobile Plant]

[Abstract] A radical improvement over the current model LuAZ-969M cross-country car is the new model LuAZ-1302 four-seat passenger car, designed for good performance on poor roads with all the good features of LuAz-969M model. Its main advantages are superior roadability, excellent economy, easy repairability, low operating cost, adaptability to varying weather conditions, and adequate availability of spare parts. Superior roadability is ensured by a full-range transmission system with simple manual gear down-shifting and interlocking of the rear-axle differential as well by the 280 mm high road clearance. On good roads at speeds up to the top 100 km/h the car is shifted into front-wheel drive, into rear-wheel drive then being shifted only for negotiating rough stretches. The car has a new engine, the MeMZ-245-20 liquid-cooled internal-combustion engine with a 24% higher power rating and an average 16% lower fuel consumption (7.7 liters per 100 km at 60 km/h) than the LuAZ-969M engine. The cooling system consist of a VAZ-2108 (Volzhsk Automobile Plant) radiator with a TS 103 automatic thermostat, an ME272 electric fan with an automatic switch, a ZAZ-1102 (Zaporozhye Automobile Plant) expansion cup, a set of valves, and a set of hoses. The contactless ignition system consists of spark plugs, an ignition coil, a magnetoelectric sensor with automatic advance angle regulator, and a transistorized distributor. The exhaust system includes a manifold and a muffler. The power transmission system includes a single-disk clutch with a diaphragm spring and a hydraulic drive. The steering wheel is equipped with a special mechanism, a four-bar linkage with lateral and longitudinal rods, which provides wheel control and directional stability on wet, snow-covered, and icy roads. The car has 175/80R13 radial tires, which reduce fuel consumption by 4% and generate less noise. They also lengthen the coasting from 50 km/h by 10%. The car can climb slopes of up to 30° and turn to a 5.5 m small radius. The body frame is an open one with Π-form side members and crossheads made of 25 mm gage sheet steel. The car should be able to run up to 10,000 km maintenance-free. It is furnished with state-of-the-art lights, electric accessories, safety equipment, and seating facilities. Figures 1; tables 1.

"Gibrid" (Hybrid) Diesel-Turbine Set: Promising Power Unit

917F0090B Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 7, Jul 90 p 11

[Article by A.K. Alyakrinskiy, V.A. Lebedev, and A.A. Sheypak, Moscow Institute of Automotive Power]

UDC 621.43.068:621.43.018.3

[Abstract] Improving the fuel economy of the automotive diesel engine by combining it with a steam turbine into a binary-cycle operation is considered, inasmuch as combining it with a gas turbine into a Rankine-cycle operation has not fully met all expectations. Mathematical models based on the applicable equations of heat and mass transfer and on the relevant characteristics of the working fluid have been constructed for a performance and design analysis of such a set. The economizer consists of a steam turbine in front of the diesel engine and a steam generator which utilizes the diesel engine exhaust heat. The fan is mounted on the turbine shaft behind the radiator. The system includes a coolant pump and a coolant-to-air heat exchanger. The optimum configuration of such an economizer and the parameters of its operating cycle are largely determined by the boiler pressure. The economizer is most effective, saving up to 26 g/kWh of fuel, when the diesel-turbine set operates at maximum torque and becomes useless when the boiler pressure falls below 0.4 MPa. Figures 1.

New Grinding Method

917F0090D Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 7, Jul 90 pp 23-24

[Article by A.M. Vasilyev, V.V. Mazurkevich, and I. Mirzamidinov, Moscow Institute of Automotive Mechanics]

UDC 621.923.04

[Abstract] A new grinding method has been developed, particularly for automobile shafts, which combines simplicity of equipment with high dimensional precision including the concentricity of center-feed grinding and the high productivity of centerless grinding. The workpiece is held in centers which are free to move transversely relative to the feed and is ground simultaneously by two wheels on opposite sides. The lathe attachment with such centers includes V block rigidly mounted on the bed which facilitates transverse motion and, throughout the grinding operation, ensures steady uniform contact with both wheels despite their different wear rates. On this V block lies a table carrying both the headstock and the tailstock, the latter with a spring-loaded center. A cylindrical guide jig underneath allows the table to be tilted relatively to the V block, but the angle of rotation is limited by a rigid stop. The dimensional precision can by this method be maintained within 8-10 μm. Figures 1.

Laser Drills Spray Nozzle Orifices

917F0090F Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 7, Jul 90 pp 25-26

[Article by G.B. Kuligin, candidate of technical sciences, A.A. Akilov, and V.I. Suponin, Scientific-Industrial Association NIITavtoprom (Automobile Industry's Scientific Research Institute of Technology)]

UDC 621.951:621.375.826

[Abstract] In order to drill high-quality orifices in fuel injectors such as the four orifices 0.3+/-0.08 mm in diameter through 0.8 mm thick spherical nozzle walls of fuel injectors manufactured at the Yaroslavl Diesel Plant, it has been found necessary to resort to a new technology involving the use of a laser beam. This technology is now used mostly for rough drilling and, therefore, needs to be modified for fine drilling. An experimental study has revealed that laser drilling in the monopulse mode involves so much energy in the single pulse that the hole becomes distorted as a result of melting of the metal around its edges and molten metal splashing into the laser beam. Drilling with a repetitively pulsed laser beam containing much less energy in each pulse was found to produce holes with a higher shape stability and a higher dimensional precision. The latter technique was, therefore, adopted and further tested. Holes were drilled with two different energy distributions in the laser beam corresponding, respectively, to an exactly and not quite exactly aligned optical laser cavity. The results of this study indicate that, with an exactly aligned laser cavity, it is feasible to drill small holes with diameters down to 0.4 mm. They indicate further that there is an optimum pulse repetition rate, namely 20 Hz, above which the metal becomes overheated and the hole becomes distorted. There was also established a 4 J upper energy limit, above which a wide enough zone around the hole can form where phase transformations occur causing the fuel injector to prematurely fail. Ensuring dimensional stability of a high-volume production item will, moreover, require refinement of this technology: use of high-quality laser crystals, use of additional diaphragms in the optical system, and rotation of the blank during the drilling operation. In the study Ye.V. Kosheverskiy, candidate of physical and mathematical sciences also participated. Figures 1.

Supplementary Air Injection and Resulting Engine Performance Indicators

917F0090C Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 7, Jul 90 p 15

[Article by N.P. Samoylov, Kazan Institute of Agriculture, and L.I. Vakhoshin, Scientific Research Institute of Automobiles and Automobile Engines]

UDC 621.43-443:621.43.018.7

[Abstract] Improving the fuel economy of an internal combustion engine by supplementary air injection into its cylinders is considered, this method having been tested on the UD-15 single-cylinder engine and the ZMZ-4021-10 (Zaporozhye Automobile Plant) four-cylinder engine. Holes were drilled in the bottom part of a cylinder, at a 10-12° angle to both diametral and axial planes so as to ensure a more uniform distribution and a better turbulization of the supplementary air. When the piston was in the lower dead-point position, air under a gage pressure of 0.3-0.5 MPa was admitted into the cylinder through a check valve which prevented entrance of exhaust gases. Measurements were made with the UD-15 engine running at 2600 rpm and with the ZMZ-4021-10 running at 1500 rpm (49% nominal speed). Calculations based on the readings have yielded the dependence of the total air excess ratio $\alpha_{S]reset - \alpha_0}(1+ C)$ and of the regular air excess ratio (without supplementary air) as well as of both air and fuel consumption rates (kg/h) on the air boost factor C over its 0-0.32 range. Both air and fuel rates were found to drop with increasing supplementary air supply, confirming the advantages of supplementary air injection. Addition of 32% more excess air not only lowered the fuel consumption by an average 10-12% but also resulted in a more uniform, stable, and reliable ignition of the mixture, a more stable and intense burning of the mixture, and a wider range of stable engine operation. Figures 2.

Specialized SAIR-16 Automatic Interactive Control System

917F0090G Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian NO 7, Jul 90 pp 26-27

[Article by N.V. Gusakov, candidate of technical sciences, Moscow Institute of Automotive Mechanics, and V.V. Oborotov, Automobile Plant imeni Lenin Komsomol]

UDC 629.113.001.5

[Abstract] The open multipurpose SAIR-16 automatic interactive control system has been adopted for the automobile manufacturing process, with any 16-digit general-purpose minicomputer which uses the RV or RVM operating system and the FORTRAN program language. The key component of the system is a monitor which generates and maintains a data zone in the random-access memory. The other functional modules are designed for signal input and output, data processing, analysis of random processes, storage of data files, graphic display, auxiliary operations, and service operations. The one set of signal input and output modules contains analog-to-digital and digital-to-analog converters for read-in and readout of shock and vibration data covering a wide frequency range (from fractions of 1 Hz to 100 kHz). The largest number of programs is contained in the packet for analysis of random processes. Data files can be stored in the peripheral memory. Graphic display programs are contained in the noninteractive GRAFOR packet, supplemented with modules for display of data blocks, and in a set of interactive visualization subsystem modules. The auxiliary modules are designed for modifying the parameters of the data zone and its blocks. The entire software for this system is designed for use during preliminary rough and subsequent more precise data processing, also for use of information based on results of experimental studies including laboratory tests of prototype automobile components.

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